

Research Project Report

(PSY9188/C85RES)

University of Lincoln
School of Health, Life and Social Sciences

Doctorate in Clinical Psychology

2010

**Evaluation of the Repeatable Battery for the
Assessment of Neuropsychological Status (RBANS)
for Sensitivity and Specificity in Screening for
Cognitive Impairment Following Stroke: A Pilot Study**

Steven Green, BSc(Hons) MSc

Submitted in part fulfillment of the requirements for the
Doctorate in Clinical Psychology

TABLE OF CONTENTS

| | |
|----------------------------------|------------|
| Abstract | 3 |
| Statement of Contribution | 5 |
| Journal Paper | 6 |
| Extended Paper | 39 |
| Appendices | 136 |

ABSTRACT

Background: Up to 70% of stroke patients experience cognitive impairment in at least one cognitive domain. Guidelines currently recommend that stroke patients be screened as soon as is reasonably practicable for potential cognitive impairment. For a screening test to be diagnostically valid it needs to demonstrate adequate levels of sensitivity and specificity. Cognitive impairment can be identified globally or as an impairment in a specific cognitive domain. Research into commonly used screening tests for cognitive impairment has failed to identify a test with adequate levels of sensitivity and specificity for cognitive impairment in an acute stroke population. The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) has demonstrated adequate diagnostic validity in differing diagnostic groups and has shown to be appropriate for use with acute stroke patients. However, the RBANS has not yet been evaluated for sensitivity and specificity for cognitive impairment following stroke.

Aims: The aim of this pilot study was to establish whether an extended study of the diagnostic validity of the RBANS as a sensitive and specific screening test of post stroke cognitive impairment was justified. The study objectives were to compare the RBANS scores with full neuropsychological test battery overall conclusions for cognitive impairment and non-impairment, to compare the RBANS with measures of impairment in specific cognitive domains, and to identify RBANS optimum cut-off scores for discrimination of cognitive impairment / non-impairment in an acute stroke population.

Methods: This study used a cross sectional design. Stroke patients admitted to a large city hospital were considered as potential participants. Patients were excluded if they had language impairment as identified by the Sheffield Screening Test, were aged over 80 years old, had had a previous stroke or neurological impairment, and had hearing or sight difficulties that precluded them from completing cognitive testing. Recruited participants completed the RBANS and a 'gold standard' battery of neuropsychological tests. Comparison of the two tests were made to identify levels of sensitivity and specificity on

global and domain specific cognitive impairment. Analysis was completed to identify RBANS optimum cut of scores for identifying global and specific cognitive impairment.

Results: 40 participants were recruited. The RBANS demonstrated poor levels of sensitivity (52%) and good levels of specificity (100%) for global cognitive impairment when using the manual recommended cut off scores. Receiver Operating Characteristic curve analysis identified an optimum cut off score for RBANS Total scale of 102.5 that provided excellent sensitivity (100%) and adequate specificity (83%), and index scores that showed adequate levels of sensitivity and specificity to domain specific cognitive impairment with the exception of Attention.

Discussion: It was tentatively concluded that the RBANS demonstrated acceptable diagnostic validity, though problems were highlighted with the Attention index and the use of a test of visual memory within the full battery that placed a heavy burden on motor skills. Recommendations were made for potential improvements to the study design and procedure, and it was suggested that further research into the evaluation of the RBANS as a sensitive and specific screening test of post stroke cognitive impairment justified and potentially feasible.

STATEMENT OF CONTRIBUTION

The idea for a research project to evaluate the RBANS for sensitivity and specificity in screening for post stroke cognitive impairment came from Prof. Nadina Lincoln. Prof. Lincoln acted as the Clinical Research Supervisor for the Trainee (Author) and supported the Trainee by providing access to participants and research assistants, as well as offering support and guidance in the development of the project and the ethical approval process. Dr Mark Gresswell acted as the Academic Research Supervisor, offering advice and guidance on the development and timeline of the study. The Trainee contributed to the project design and was responsible for developing and submitting the proposal for ethical approval and responding to requests for clarification. The Trainee also completed the literature review for the project. Potential participant were identified and approached to participate in the project by Emma Rogers (Assistant Psychologist) who was also a member of the permanent ward staff, and was aided in this by members of the ward nursing team. Consent to participate was taken by the Trainee, or by Emma Ford (Research Assistant) or Alex Gaskill (Assistant Psychologist): both Emma Ford and Alex Gaskill also administered and scored the RBANS. Alex Gaskill also provided support in collating information and organising the administrative parts of the project. The full battery testing was administered and scored by the Trainee. All clinical assessments were done under the supervision of Dr Vanessa Dale (Clinical Psychologist), who also aided in the identification of potential participants. Data entry and analysis was completed independently by the Trainee.

JOURNAL PAPER

written for
The International Journal of Stroke

**Title: Evaluation of the Repeatable Battery for the
Assessment of Neuropsychological Status
(RBANS) as a screening test of post-stroke
cognitive impairment: A pilot study**

Author: Steven Green

Affiliate: University of Lincoln

Address: Trent Doctorate in Clinical Psychology

Health, Life and Social Sciences

1st Floor, Bridge House

University of Lincoln

Brayford Pool

Lincoln

LN6 7TS

Email: 08127475@students.lincoln.ac.uk

Abstract

Background: Cognitive impairment following stroke is common. Current national guidelines recommend that survivors of stroke are screened for impairment as soon as is practicably possible. Evaluation of commonly used screening tests have shown that none have the required levels of sensitivity and specificity to perform this task. The RBANS may be a suitable screening test for post stroke cognitive impairment.

Aims: To conduct a pilot study to establish whether extended research was justified for evaluating the sensitivity and specificity of the RBANS as a screening test for post stroke cognitive impairment. The study objectives were to evaluate the RBANS Total Scale and Index score conclusions' for global and domain specific cognitive impairment following stroke, when compared to full battery neuropsychological testing.

Methods: A cross-sectional design was used. Eligible participants were recruited from the stroke wards of a large city hospital. Participants were initially administered either the RBANS or full battery testing followed by administration of the alternative testing with a researcher blind to the previous results. Test scores were categorised as impaired or non-impaired on measures of global cognitive functioning and specific cognitive domains.

Results: Analysis of the RBANS Total Scale and Index scores for 40 participants showed it to have good levels of sensitivity and specificity for global and domain specific cognitive impairment when using cut off scores identified

by ROC curve analysis, though no optimum score was identified for the Attention index.

Conclusions: The RBANS was a potentially valid test of post stroke cognitive impairment, demonstrating good sensitivity and specificity to global and domain specific cognitive impairment with the exception of the Attention index. Further evaluation of the RBANS was recommended.

Introduction

Cognitive problems following stroke are common. It has been reported that up to 70% of acute stroke patients present with clinically significant cognitive impairment in at least one cognitive domain (1), and that cognitive impairment (along with right leg problems) is the most common residual impairment following stroke (2). Whilst most stroke research has focused on the physical rather than cognitive consequences of stroke (3), cognitive impairment is thought to be an important predictor of longer-term difficulties for stroke patients, including longer in-patient stays, less responsiveness to treatment, and greater loss of independence (4). The National Clinical Guidelines for Stroke currently recommends that stroke patients should be screened for possible cognitive impairment as soon as is reasonably practicable (5). (See extended paper 1.1 - stroke epidemiology).

Screening for cognitive impairments saves the time and cost of administering a full battery of neuropsychological tests, which can be administered following screening if impairments are detected and require further investigation. Screening for post stroke cognitive impairment can contribute to the psychological support of survivors of stroke and their families in several respects. Screening can be useful in terms of planning future testing needs, monitoring changes in cognitive status over time, and can contribute to identifying future support needs and interventions (6). Also, cognitive impairment has a significant co-morbidity with post stroke depression and other

mood disorders (7), and screening can help inform a wider biopsychosocial understanding of an individual's emotional, as well as physical and cognitive, response to stroke (8), with interventions for post stroke depression being shown to aid functional recovery as well as helping the survivor and their families to adjust to the impact of a stroke. (See extended paper 1.3 – Clinical Psychology and Stroke).

Ideally, a screening test should be quick and easy to administer, meaning that in practice it can be administered at the patient's bedside and completed within about 10 minutes (9). A screening test can be weighted to identify clusters of cognitive impairments to aid a diagnosis (as in dementia screening tests), or more globally focused to either screen for the presence or absence of cognitive impairment generally or to highlight potential impairments within particular cognitive domains. (see extended paper 1.2 cognitive screening).

Cognitive domains have been variously categorised and include those of memory, executive function, visual perceptual abilities, attention, planning movement (praxis), and language (10). (See extended paper 1.4 cognitive domains). Cognitive impairment following stroke will depend on the site of the blockage or bleed and the extent of the resultant damage. As the stroke can occur in any part of the brain, any or all of these cognitive domains can be affected with varying degrees of severity, and thus there is no common pattern of cognitive impairment following stroke (11). Equally, these domains comprise of sub-domains (for instance, memory being sub-categorised in immediate and

delayed, verbal and visual memory, and for a screening test following stroke to be effective, it should be able to detect impairment in any cognitive domain, with the implication that it should be able to identify impairment of any sub-domain (See extended paper 1.5 cognitive impairment and stroke).

A screening test is considered to be diagnostically valid if it demonstrates acceptable levels of sensitivity and specificity. Sensitivity relates to the test's ability to identify all patients with impairment, specificity to the test's ability to not include someone without impairment (4). In practice, there is a trade off between sensitivity and specificity, and acceptable rates are generally agreed to be 80% agreement or higher for sensitivity, and 60% or higher for specificity (12). The cut-off score on a test that gives optimal sensitivity and specificity can be calculated using Receiver Operator Characteristic (ROC) curves. The Area Under the Curve (AUC) can range from 0.5 to 1, where 1 means 100% sensitivity and specificity. However, a test that has low sensitivity in one or more cognitive domain may still be acceptably sensitive to global cognitive impairment, and thus fail to identify certain groups of people with cognitive impairments. Therefore, when evaluating a test for specificity and sensitivity, sub-scales as well as total scores need to be evaluated. (see extended paper 1.6 diagnostic validity / sensitivity & specificity).

Several tests exist to screen for cognitive impairment, though it is important that these measures "have been well validated in the populations for which they are intended to be used" (10, p790). The Mini-Mental State Examination (MMSE) (13) is the most commonly used test to screen for cognitive impairment

following stroke, and is the test currently suggested by the Royal College of Physicians (5).

Originally designed as a screening test for dementia and delirium, the MMSE has come to be used as a screening test for global cognitive impairment (1). However, evaluation for its use in screening for post-stroke cognitive impairment has shown it to be unsuitable for this purpose. Nys *et al* (1) concluded that with a cut-off score of <24 , the MMSE only yielded sensitivity of 35% for cognitive impairment in acute stroke patients, and an optimal cut-off score could not be identified. Further, the only cognitive domain that the MMSE showed any sensitivity to was verbal memory (correctly identifying 4 out of 5 patients), and it failed to identify patients with reasoning disturbances, executive dysfunction, and visual perceptual impairments.

The Middlesex Elderly Assessment of Mental State (MEAMS) has also been evaluated as a screening test for post-stroke cognitive impairment. Cartoni and Lincoln (4) reported that the MEAMS demonstrated good specificity (100%) but poor sensitivity (52%) comparison for total score and overall conclusions for impairment, using a cut-off of 3 or more fails. Sensitivity improved to 81% (with 50% specificity) when using 3 sub-tests to identify cognitive impairment in language, perception or memory. Sensitivity to executive functioning impairments was reported to be exceptionally poor at 11%. (see extended paper 1.7 evaluation of screening tests).

The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) (14) is a potential alternative screening test for post stroke cognitive impairment. Originally developed as a screening test for dementia in older adults, the RBANS can be administered at a patients bedside, and despite taking between 20 to 30 minutes to administer, has been described as being well tolerated even by severely ill patients (15). It comprises of 12 sub-tests that are combined to form 5 index scores and a total score. The 5 indexes are Immediate Memory, Delayed Memory, Visuospatial/Constructional, Language, and Attention. (see extended paper 1.8 further description of RBANS).

It has been reported that the RBANS has demonstrated excellent diagnostic validity for cognitive impairment in dementia (16) as well as demonstrating good validity in screening for cognitive impairment in diagnostically heterogeneous groups (16). The RBANS has also demonstrated good validity with differing specific populations, including people with schizophrenia (17), adolescent psychosis (18), multiple sclerosis (19), traumatic brain injury (20), and end-stage liver disease (21), though these studies have tended to focus on evaluating the RBANS as a measure of overall cognitive impairment, rather than identifying impairment in any particular domain.

A number of studies have been undertaken relating to the use of the RBANS with stroke patients, though several of these have been completed outside of the UK and hence caution should be applied when comparing to these conclusions to a UK population, as differences in clinical practice and cultural factors may compromise such comparisons. Support for the ecological validity

of the RBANS index scores with stroke patients has been reported by Larson *et al* (22). Hoyle *et al* (23) reported that the RBANS could differentiate the hemispheric side of the stroke, and Wilde (24) that the RBANS was a potentially valid measure of executive dysfunction in stroke patients, despite not having this as an index score. A single case study of a 22 year old psychiatric patient who suffered a stroke following screening with the RBANS suggested that the RBANS demonstrated sensitivity to pre and post stroke cognitive impairment variations (25). However, an evaluation of the sensitivity and specificity of the RBANS as a screening test for post stroke cognitive impairment is currently missing from the research literature. (see extended paper 1.9 RBANS and stroke).

The aim of this pilot study was to establish whether an extended study into the diagnostic validity of the RBANS as a sensitive and specific screening test for post stroke cognitive impairment was justified. The study objectives were to compare the RBANS scores with full neuropsychological test battery overall conclusions for cognitive impairment and non-impairment, to compare the RBANS with measures of impairment in specific cognitive domains, and to identify RBANS optimum cut-off scores. (see extended paper 1.9 aims).

Methods

Participants

(see extended paper 2.1 sample size)

Participants were recruited from the acute stroke wards of a large inner city hospital that admitted approximately 800 people following a stroke per annum. Patients were considered appropriate for inclusion in the study if they had suffered a stroke. In practice this meant that all patients admitted to these wards were considered as meeting the criteria for inclusion in the study. Patients were excluded from the study if they were unable to give informed consent (see extended paper 2.2 consent), had aphasia (as determined by a score of <15 on the Sheffield Screening Test (12) if this test had been administered as part of the routine intake assessment, otherwise aphasia was determined on consultation with the ward Occupational Therapists), were unable to complete the tests due to visual or auditory impairments, or had a neurological, psychiatric or dementia diagnosis prior to the stroke. Patients who did not speak English were also excluded, as the tests have not been validated for other languages, as were patients aged over 80 as several of the battery tests were not adequately validated for use over this age. Patients were not explicitly excluded if they had had a Transient Ischemic Attack (TIA), though in practice these patients were not included as they were not admitted to the acute stroke wards from the hyper-acute ward. Participants were withdrawn from the study if they suffered a further stroke or complications.

Materials

All the test score sheets and results were anonymised by replacing the participants name with a study ID number. Baseline data, including the participants age, gender, and level of education were recorded as per the front page of the RBANS, and these were used to compare with norms for identifying cognitive impairment on all the tests. The second page of the RBANS (Information and Orientation) was not completed as this contained participant identifiable information and did not provide scoring information relevant to the study. The site of the stroke was documented from the medical record as identified by CT scan. RBANS Total Scale and index scores below 69 were classed as cognitively impaired as per the manual (14).

The neuropsychological test battery was comprised of selected sub-tests from larger test batteries in order to provide the data for global and domain specific impairment or non-impairment needed for the study, without subjecting participants to extensive and unnecessary (in terms of the study) testing. The test battery and selected sub-tests, as well as the assessed cognitive domain, are listed in table 1. The tests were completed in the order presented in table 1 to allow for the time delays required for the testing of delayed memory. A measure of language impairment was not included as patients with aphasia had already been excluded from the study, though the battery included the short NART to estimate pre-morbid IQ and a test of verbal fluency (the COWAT) to assess for executive functioning ability. The tests were scored according to the

relevant test manuals and published normative data, with classification of impairment being made if a participant scored below the 5th percentile on any one sub-test. The individual sub-tests were selected to measure sub-domains of potential impairment within a particular domain (for instance, the selected tests from the VOSP measure separate aspects of Visuospatial ability, namely object and space perception, and the Logical Memory and Rey Figure tests, to assess verbal and visual memory). This wide ranging approach to battery testing was taken to allow for focal impairments to be identified within the context of the heterogeneous presentation of potential impairment following stroke, and is in line with good practice for exploratory neuropsychological assessment as recommended by Lezak *et al* (7). Consequently, for a screening test of cognitive impairment following stroke to be diagnostically valid, it should be sensitive to impairment of these differing sub-domains, and so impairment of any single test within the full battery resulted in the participant being categorized as CI. A full battery test was considered void if the results were affected by a separate cognitive or non-cognitive difficulty. Classification of impairment at the 5th percentile was comparable to the scoring procedure used by Nys *et al* (1), though other comparable studies did not report their cut-off points (4, 12). (see extended paper 2.3 cut-off point). (see extended paper 2.4 neuropsychological test battery).

Table 1. Test battery name, selected sub-tests and cognitive domain used in the full neuropsychological test battery.

| <i>Test Battery Name</i> | <i>Selected Sub-Test</i> | <i>Cognitive Domain Assessed</i> |
|---|---|----------------------------------|
| Wechsler Memory Scale III (WMS III) (26) | Logical Memory I | Immediate memory |
| Rey Complex Figure (27) | Copy | Visuospatial |
| WMS III | Digit Span | Attention |
| Rey Complex Figure | Immediate Recall | Immediate memory |
| WMS III | Letter/Number Sequencing | Attention |
| Behavioural Inattention Test (BIT) (28) | Star Cancellation | Visuospatial |
| Visual Object and Space Perception Test (VOSP) (29) | Incomplete Letters, Dot Counting, Position Discrimination | Visuospatial |
| Controlled Word Association Test | FAS | Executive function |

| | | |
|---|-----------------------------------|--------------------|
| (COWAT) (30) | | |
| Short National Adult Reading Test (Short NART) (31) | Full test | Pre-morbid IQ |
| WMS III | Logical Memory II | Delayed memory |
| Rey Complex Figure | Delayed Recall | Delayed memory |
| Modified Card Sorting Test (MCST) (32) | Full test | Executive function |
| Hayling and Brixton Test (33) | Brixton Spatial Anticipation Test | Executive function |

Procedure

Patients considered eligible for inclusion in the study were approached by a member of the healthcare team (usually a ward staff nurse) for potential participation in the study and given a patient information sheet. After 48 hours, informed written consent to participate was taken by a member of the research team and the first set of tests (either the RBANS or full battery) was completed.

Potential participants were identified through weekly meetings between the research team and ward staff, and approach for participation was made as soon as was practicably possible following admission to the ward from the hyper-acute ward. Both the researchers were present on the wards for two days per week to allow administration of the tests to be completed as closely as possible to each other, with an expectation that this should not be longer than five days, in order to minimize the effect of potential change in cognitive status due to spontaneous recovery. Initial administration of either the RBANS or full neuropsychological battery was alternated to control against order bias. Researchers were unaware of the results from previously administered tests to control against investigator bias.

After completion of either the RBANS or full battery, the participant was informed that they would be approached by a separate member of the research team to complete the alternate set of tests. The RBANS took between 20 to 30 minutes to complete and was administered at the participant's bedside. The full battery testing took between 1 to 1½ hours to complete, and was completed in a separate room if this was available and appropriate. These tests were then

scored and filed securely. If the participant had been discharged, then an appointment was made with the participant to complete the testing at a convenient location. If the participant had suffered a change in their condition between test administration then continuation in the study was discussed with the healthcare team. The chief investigator collated the results of all the tests at the end of each week. A summary report was later completed by the research team and filed in the participants' notes. (See extended paper 2.5 further details of research procedure).

Statistical analysis

Data was analysed using the Predictive Analytics Software (PASW) programme version 17. Data was coded as indicating participants as clinically impaired (CI) or non-clinically impaired (NCI), based on the cut-off scores outlined above. Sensitivity and specificity were calculated by comparing agreement and disagreement between two tests of CI/NCI. Positive predictive values (PPV) and negative predictive values (NPV) were also calculated.

Comparison were made between RBANS total score and battery test total scores and between index scores and battery test conclusions for executive function, visuospatial perception, attention, immediate memory, delayed memory and language.

Receiver Operating Characteristic (ROC) curves were calculated for the RBANS Total scale/Total CI/NCI as measured by the test battery, and for the

RBANS index/Test battery specific conclusions, to identify RBANS optimum cut-off scores in relation to sensitivity and specificity.

Ethical Approval

Ethical approval was granted by a local NHS Research Ethics Committee, the University of Lincoln, and site specific NHS R&D departments. No risks to participants, investigators, or NHS trusts, resulting from taking part in this study, were identified. (see extended paper 2.6 ethical approval).

Results

(See extended paper 3.1 Normality of Distribution)

Demographic details

During the recruitment phase of the study, 390 patients were admitted the hospital stroke wards of whom 146 (37%) met the study inclusion criteria and were approached to participate. A total of 47 patients (32% of patients who met the inclusion / exclusion criteria) consented to participate, of which 7 (15%) did not complete the full testing as 3 were discharged before completing all tests, one had visual difficulties, one became unwell during testing, and 2 declined to participate further. Testing took on average one hour to complete the full battery and 20 minutes for the RBANS, and did not appear to be a factor in patients' decisions regarding participation or participants' withdrawal from the study. Of the 40 participants, 25 (62%) were male. Age ranged from 30 to 80 years (mean age 68.65, SD 12.91) and years of education from 8 to 16 (mean 10.70, SD 3.15). Twenty-two (55%) participants had a right hemispheric stroke, 15 (37.5%) had a left hemispheric stroke and 2 (10%) had a bilateral stroke. Ischemia was the cause of stroke in 35 (87.5%) of participants and haemorrhage the cause in 4 (10%) participants: hemisphere and cause was not recorded for one (2.5%) participant. The stroke was classified as total anterior circulation syndrome in 14 (35%) participants, partial anterior circulation syndrome in 9 (22.5%), posterior circulation syndrome in 1 (2.5%), and lacunar circulation syndrome in 13 (32.5%), with classification not recorded for 3 (7.5%) participants. The mean interval between onset of the stroke and completing the testing process was 22 days (SD 17) and the mean interval

between the first and second test was 3 days (SD 4). (See extended paper 3.2 demographic details).

Descriptive details

The conclusions of the full neuropsychological test battery identified 33 participants (82.5%) as having an impairment in at least 1 cognitive domain. More specifically, 60% of participants were identified as having an impairment in visuospatial abilities, 60% in executive functioning, 52% in attention, 47.5% in delayed memory, 27.5% in immediate memory, and 20% in language. When using the suggested cut-off score of 69 (13) on the Total Scale index, the RBANS identified 17 participants (42.5%) as having a cognitive impairment. When using the RBANS individual index scales to identify whether a participant had an impairment in one or more cognitive domain, this rose to 27 participants (67.5%) being identified as cognitively impaired. Specifically, the RBANS identified 50% of participants as having an impairment in visuospatial abilities, 40% in attention, 40% in delayed memory, 35% in immediate memory, and 15% in language. (see extended paper 3.3 further descriptive details). Several participants were categorised as cognitively impaired in more than one cognitive domain: the number of cognitive domains identified as impaired by the RBANS (at the manual suggested cut off score) and full battery (excluding executive functioning) per participant is summarised below in table 2. (Table 2 presents the total number cognitive domains for participants identified as impaired / non-impaired as opposed to a running total).

Table 2. Number of cognitive domains categorised as impaired per participant for RBANS and Full Battery conclusions.

| Number of domains impaired | Number of participants identified | |
|----------------------------|-----------------------------------|--------------|
| | RBANS | Full Battery |
| 0 | 13 | 7 |
| 1 | 6 | 10 |
| 2 | 8 | 8 |
| 3 | 6 | 7 |
| 4 | 4 | 3 |
| 5 | 3 | 5 |

Diagnostic validity

(see extended paper 3.4 diagnostic validity using recommended cut-off scores).

Analysis of the RBANS conclusions for impairment when using cut-off scores of <69 showed that the only measure to provide an acceptable level of sensitivity and specificity was for global conclusion of cognitive impairment when identified by impairment on 1 or more index score (sensitivity = 81 [95%CI =64-92], specificity = 100 [95%CI = 56-100]). All other measures identified either acceptable levels of sensitivity or specificity, but combined levels could not be identified.

ROC analysis suggested that the RBANS Total Scale was able to identify global cognitive impairment (AUC = 0.96, $p < 0.001$), and the RBANS Indexes were able to identify impairment in all the specific cognitive domains. The Visuospatial/Constructional Index had the highest diagnostic accuracy (AUC = 0.97, $p < 0.001$) when compared to full battery visuospatial domain specific conclusions, followed by: Delayed Memory (AUC = 0.82, $p < 0.001$), Immediate Memory (AUC = 0.82, $p < 0.002$) and Attention (AUC = 0.76, $p < 0.01$). RBANS Total Scale showed the highest diagnostic accuracy to executive function impairments (AUC = 0.89, $p < 0.001$) and Language the lowest (AUC = 0.78, $p = 0.03$). RBANS optimum cut-off scores for sensitivity and specificity were identified by ROC analysis for global and domain specific cognitive impairments, when compared to the full battery conclusions, and are presented in table 3 along with positive and negative predictive values. Acceptable levels of sensitivity, specificity, PPV and NPV are highlighted. (see extended paper 3.5 Cross Tabulation and 3.6 ROC and AUC conclusions)

Table 3. Sensitivity, specificity, positive and negative predictive values for RBANS conclusions based on ROC identified optimum cut-off scores

| RBANS Index <i>(Cut-off score)</i> | <i>Sensitivity</i> <i>(95% CI)</i> | <i>Specificity</i> <i>(95% CI)</i> | <i>Positive</i> <i>Predictive Value</i> <i>(95% CI)</i> | <i>Negative</i> <i>Predictive</i> <i>Value (95%</i> <i>CI)</i> |
|--|---------------------------------------|---------------------------------------|---|---|
| Total Scale | 100% | 83% | 94% | 100% |
| (102.5) | (87-100) | (30-94) | (79-99) | (46-100) |
| Immediate | 82% | 72% | 53% | 91% |
| Memory | (48-97 | (53-87) | (29-76) | (70-98) |
| (79.5) | | | | |
| Visuospatial | 100% | 75% | 88% | 100% |
| (88) | (82-100) | (47-92) | (66-95) | (70-100) |
| Attention | 86% | 47% | 64% | 75% |
| (86.5) | (63-96) | (25-70) | (44-81) | (43-93) |
| Delayed | 94% | 61% | 69% | 93% |
| Memory | (72-99) | (39-81) | (48-85) | (64-100) |
| (90.5) | | | | |

Discussion

A superficial review of the results would suggest that the RBANS has strengths and weaknesses as a diagnostically valid test for the screening of post stroke cognitive impairment. When using the manual suggested cut off scores (15), the RBANS was poor at discriminating between overall impairment and non-impairment on the total scale and on domain specific impairment or non-impairment on any index. However, the test did demonstrate adequate sensitivity and specificity to overall cognitive impairment when an impairment was identified on one or more indexes, indicating that the RBANS may have been measuring similar constructs to the full battery but labelling them under different domains.

Using ROC curve analysis, cut off scores were identified that gave good to excellent levels of sensitivity and specificity for global and domain specific cognitive impairment with the exception of attention, which demonstrated adequate sensitivity but poor specificity. It is possible that this may have been due to the RBANS assessing attention using 'Coding', which incorporates motor skills and may have disadvantaged participants who had physical difficulties resulting from their stroke, and was not picked up by the full battery attention tests of Digit Span and Letter/Number Sequencing. It should also be noted that the ROC analysis identified an RBANS optimum cut off score of 102.5 on the total scale, which is at approximately the 51st percentile of the normative sample. This point was identified as it gave the optimum balance between

sensitivity (100%) and specificity (71%) with sensitivity being preferred over specificity. However, ROC analysis identified that a cut off score of 83.5 resulted in adequate sensitivity (82%) and excellent specificity (100%), with this cut off point being at slightly greater than 1 sd below the mean, and equivalent to the RBANS optimum cut off point reported by Duff *et al* (16). An explanation for the identification of 102.5 as the optimum cut off point would be that the low number of participants identified as NCI overly inflated the cut off point needed to exclude those without impairment, and future research would need to ensure that an adequate number of NCI participants were identified to allow for confidence in the ROC identified cut off point.

The Total Scale score demonstrated excellent diagnostic accuracy for executive function impairment, perhaps reflecting current thinking that executive functioning is not a homogenous construct but is related to several cognitive functions (33), and hence would not be identified on a single RBANS index but could be identified through the overall (Total Scale) conclusions. However, the clinical utility of the RBANS in screening for executive functioning impairment is severely limited by it not having a separate index for this domain: all that can be concluded from a low score on the Total Scale would be that further evaluation of executive functioning would be necessary. This could potentially be mitigated against in clinical practice by administering a short test of executive functioning ability (such as the COWAT) alongside the RBANS, though this would increase the duration of screening.

The Positive and Negative Predictive Values suggested that confidence in identification of an impairment or non-impairment was excellent for the Total Scale at a cut off score of 102.2, and for Visuospatial/Constructional impairment at a cut off score of 88. None of the other indexes demonstrated consistently high levels of confidence for both positive and negative impairment conclusions, and the Immediate Memory index was especially poor in its negative conclusions. This could be related to the higher prevalence of global and Visuospatial impairments, though at 53% the Immediate Memory PPV was barely better than chance. Even with these limitations taken into account, based on these findings the RBANS would be a suitable screening test for post stroke cognitive impairment, and offered superior diagnostic validity to that reported for the MMSE (1) and the MEAMS (4). (see extended paper 4.1 – further interpretation of results)

There are several limitations to this study. Firstly, the sample was only taken from those patients who were admitted to the stroke rehabilitation wards and as such it did not represent those patients who were discharged within 48 hours of admission to hospital. This would therefore limit the generalisability of these results for the overall stroke population and would significantly limit the validity of these conclusions for people who had a TIA, though the results would still be applicable to acute in-patient settings where the routine screening of post stroke cognitive impairment usually occurs. Secondly, whilst careful consideration went into the development of the full battery of neuropsychological tests, this battery may not have identified all potential cognitive impairments, as to standardise the test battery to cover all potential impairments would have made the testing load

intolerably high. However, conducting the pilot did allow for evaluation of the full battery, and several alterations would be recommended, including replacing the Rey Complex Figure as a test of visual memory with a non-motor task, as this test was largely invalidated for participants with physical impairment. Thirdly, the RBANS identified 6 participants as being impaired on the Language index, despite aphasia being an exclusion criterion. This was due to the SST being infrequently administered as part of the routine intake testing, and exclusion for aphasia being based on ward staff consensus rather than formal measures. Consequently, it is possible that the validity of test results may have been compromised in that participants may have produced a score indicating cognitive impairment on a particular domain when in fact the test result was due to receptive or expressive difficulties. Whilst language impairment would have applied to both the RBANS and full battery testing (and hence would effect both test conclusions) it may be that for these participants the clarity of the test administration instructions was more pertinent than the domain under examination thus introducing an extraneous variable, and it would be recommended that for an extended study, the SST be administered before proceeding with the testing. Finally, a further limitation in the interpretation of these results was the large confidence intervals due to the small sample size and small number of non-cognitively impaired participants.

Even with these limitations, the confidence intervals of this study were comparable with some of those that have been reported in other studies of screening for post-stroke cognitive impairment. Cartoni and Lincoln (4) for instance reported sensitivity of the MEAMS for post stroke cognitive

impairment at 52% with a 95% confidence interval of 32 to 71% (though this still falls short of the 80% recommended cut off point), and sensitivity of 100% with a 95% confidence interval of 29 to 100%. Nys *et al* (1) did not report confidence intervals, and had a smaller sample size than this study at 34 participants. The samples sizes of these studies also reduced considerably when exploring domain specific impairments, with Nys *et al* (1) for instance, reporting 5 participants identified by full battery testing as having visual memory deficits. Given that other studies have suggested that the RBANS has excellent diagnostic validity amongst heterogeneous populations (16), which is reflected in the impairments identified within this study, and that it has demonstrated ecological validity post stroke (22) as well as sensitivity to pre and post stroke cognitive impairment (24) (including executive dysfunction [24]), this study contributes to the body of literature on post stroke cognitive impairment by suggesting that its use as a screening test may be justified when contrasted with other comparable research.

Recruitment of stroke patients into research projects has been reported as having a consistently low consent rate, with recruitment rates of eligible patients being reported at between 10 and 50% (34), which is comparable to the consent rate of 32% of this study. There were several factors that impacted on the study's recruitment rate including the fact that several studies were being conducted on the acute stroke wards concurrently to this one, and some potential participants reported this as being a reason for non-participation. However, no potential participants explicitly cited the time commitment required

as a reason for non-participation, and no participants withdrew from the study due to this; many of the participants reported that they had enjoyed the process, and the administration of the RBANS appeared to be well tolerated, in line with other research observations (15). It should be noted however that voluntary consent means that recruited participants may not be representative of the acute stroke population, in that people may have been more likely to participate if they felt well enough to, were motivated or had confidence in their cognitive abilities, or were not incapacitated by other factors including post-stroke depression. Information on non-recruited patients was not recorded for this pilot, and it would be recommended that future research take these factors into account to allow for greater confidence (or otherwise) in the generalisation of results.(see extended paper 4.4 – critical reflection).

It is worth noting that the prevalence rates of overall impairment and domain specific impairment conclusions of the full test battery in this study were comparable with those reported previously (1,4,12). Whilst there is a relatively wide range of reported prevalence rates, and as such it may be difficult to draw conclusions, this could potentially suggest that the sample in this study was comparable to those in previous research, and therefore the conclusions could have some level of generalisability to the wider acute stroke population.

The results presented here tentatively suggest that the RBANS is potentially a sensitive and specific screening test of post stroke cognitive impairment, both as a measure of global impairment and as a screening test for particular

cognitive domains. Given the almost ubiquitous prevalence of post stroke cognitive impairment (5) it could be argued that the RBANS has clinical utility in post stroke psychological support beyond that of routine screening. Given that cognitive impairment following stroke can spontaneously remiss over a relatively short time period (10), the RBANS could be used in clinical practice to monitor change in cognitive status and in predicting which people may need more detailed assessment. With diagnostic confidence in the test results, the information gathered from screening could be useful in informing a wider formulation of the idiosyncratic impact of stroke and in exploring the meaning of this for the patient, family members and other carers, and thus help to inform interventions, either directly with the survivor and their family or indirectly with other care staff, tailored to individual compensation approaches and coming to terms with the consequences of stroke (9). Also within a wider formulation, it could be useful in predicting which survivors may benefit from focused individual intervention for post-stroke depression (8). (See extended paper 4.2 – Implications for clinical psychologists working in stroke services). As the results presented here suggest that the RBANS may demonstrate acceptable sensitivity and specificity in screening for post stroke cognitive impairment, further evaluation of the RBANS would be justified, with a sample size based on the prevalence rates for both global and domain specific cognitive impairments identified from this pilot study to allow for increased confidence in the conclusions. (see extended paper 4.4 – Feasibility of extended study and 4.5 – future research).

References

1. Nys, G.M.S., van Zandvoort, M.J.E., de Kort, P.L.M., Jansen, B.P.W., Kappelle, L.J., & de Haan, E.H.F. Restrictions of the Mini-Mental State Examination in acute stroke. *Archives of Clinical Neuropsychology* (2005). *20*, 623-629
2. Walford, H., Soljak, M., & Majeed, A. Stroke prevalence modeling briefing document. Eastern Region Public Health Observatory (2008). <http://erpho.org.uk> (accessed on May 17, 2009)
3. Donovan, N.J., Kendall, D.L., Heaton, S.C., Kwon, S., Velozo, C.A., & Duncan, P.W. Conceptualizing functional cognition in stroke. *Neurorehabilitation and Neural Repair* (2008). *22*(2), 122-135.
4. Cartoni, A., & Lincoln, N.B. The sensitivity and specificity of the Middlesex Elderly Assessment of Mental State (MEAMS) for detecting cognitive impairment after stroke. *Neuropsychological Rehabilitation* (2005). *15*(1), 55-67
5. Royal College of Physicians. National Clinical Guidelines for Stroke (3rd ed.) (2008) <http://www.rpclondon.ac.uk> (accessed on January 5, 2009)
6. Lezak, D.M., Howieson, D.B. & Loring D.W. *Neuropsychological assessment* (4th ed) (2004). New York, NY: Oxford University Press.
7. Saxena, S.K. Prevalence and correlates of cognitive impairment in stroke patients in a rehabilitation setting. *International Journal of Psychosocial Rehabilitation* (2006). *10*(2), 37-47
8. Lincoln, N. Outcome of cognitive rehabilitation in clinical stroke services. In P.W. Halligan & D.T. Wade (Eds), *Effectiveness of*

rehabilitation for cognitive deficits (2005). Oxford, UK: Oxford University Press

9. de Koning, I., van Kooten, F., Koudstaal, P.J., & Dippel, D.W.J. Diagnostic value of the Rotterdam-CAMCOG in post stroke dementia. *Journal of Neurology, Neurosurgery, and Psychiatry* (2005). 76. 263–265
10. Johnstone, B., & Stonnington, H.H. (Eds). *Rehabilitation of neuropsychological disorders: A practical guide for rehabilitation professionals* (2001). Philadelphia, PA: Psychology press
11. Skilbeck, C. Neurological assessment in stroke. In J.R. Crawford, D.M. Parker, & W.W. McKinlay (Eds.). *A handbook of neuropsychological assessment* (1992). Hove, UK: LEA.
12. Blake, H., McKinney, M., Treece, K., Lee, E., & Lincoln, N.B. An evaluation of screening measures for cognitive impairment after stroke. *Age and Ageing* (2002). 31. 451-456.
13. Folstein, M., Folstein, S., & McHugh, P. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research* (1975). 12, 78-85.
14. Randolph, C. *RBANS manual - Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)* (1998). San Antonio, Tex: Psychological Corp (Harcourt).
15. Hobart, M.P., Goldberg, R., Bartko, J.J., & Gold, J.M. Repeatable Battery for the Assessment of Neuropsychological Status as a screening test in schizophrenia, II: Convergent/discriminant validity

- and diagnostic group comparisons. *American Journal of Psychiatry* (1999). 156(12), 1951-1957.
16. Duff K., Humphreys Clark, J.D., O'Bryant, S.E., Mold, J.W., Schiffer, R.B., & Sutker, P.B. Utility of the RBANS in detecting cognitive impairment associated with Alzheimer's disease: Sensitivity, specificity, and positive and negative predictive powers. *Archives of Clinical Neuropsychology*, (2008). 23(5), 603-612.
 17. Gold, J.M., Queern, B.A., Iannone, M.A., & Buchanan, R.W. Repeatable Battery for the Assessment of Neurological Status as a screening test in schizophrenia, 1: Sensitivity, reliability, and validity. *American Journal of Psychiatry* (1999). 156: 1944-1950.
 18. Holtzer , L., Chinet, L., Jaugey, L., Plancherel, B., Sofia, C., Halfon, O., & Randolph, C. Detection of cognitive impairment with the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) in adolescents with psychotic symptomatology. *Schizophrenia Research* (2007). 95(1-3), 48-53
 19. Beatty, W.W. RBANS analysis of verbal memory in multiple sclerosis. *Archives of Clinical Neuropsychology* (2004). 19, 825-834
 20. McKay, C., Wertheimer, J.C., Fichtenberg, N.L., & Casey, J.E. The Repeatable Battery of Neuropsychological Status (RBANS): clinical utility in a traumatic brain injury sample. *Clinical Neuropsychologist* (2008). 22(2), 228-241.
 21. Sorrell, J.H., Zolnikov, B.J., Sharma, A., & Jinnai, I. Cognitive impairment in people diagnosed with end-stage liver disease

- evaluated for liver transplant. *Psychiatry and Clinical Neurosciences* (2006). *60*, 174-181.
22. Larson, E.B., Kirschner, K., Bode, R.K., Heinemann, A.W., Clorfene, J., & Goodman, R. Brief cognitive assessment and prediction of functional outcome in stroke. *Topics in Stroke Rehabilitation* (2003). *9*(4), 10- 12.
 23. Hoyer, W., Thompson, R., Sherer, M., Nick, t., Gaines, C., Collipp, D., & Vohra, R. Brief cognitive assessment after stroke: RBANS factor structure and performance patterns. *Journal of the International Neuropsychological Society* (2000). *5*, 138
 24. Wilde, M.C. The validity of the Repeatable Battery for the Assessment of Neuropsychological Status in acute stroke. *Clinical Neuropsychologist* (2006).*20*(4), 702-715
 25. Duff, K., Bellinger, L.J., Kettmann, J.D.J., & Bayless, J.D.. Pre- and post-right middle cerebral artery stroke in a young adult: A case study examining the sensitivity of the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). *Applied Neuropsychology* (2006). *13*(3), 194-200
 26. Wechsler, D.. Wechsler memory scale – third edition (1997). San Antonio, TX: Pearson.
 27. Meyers, J.E., & Meyers, k.R. Rey complex recognition test and trial (1995). Odessa, FL: Psychological Assessment Resources.
 28. Wilson, B.A., Cockburn, J., & Halligan, P. Behavioural Inattention Test (1987). Bury St. Edmunds, UK: Thames Valley Test Co.

29. Warrington, E.K., & James, M. Visual Object and Space Perception Battery (1991). Bury St. Edmunds, UK: Thames Valley Co.
30. Benton, A.L., & Hamsher, K.deS. Multilingual Aphasia Examination Manual (1989). University of Iowa, Iowa City, IA.
31. Beasrdsall, L., & Brayne, C. Estimation of verbal intelligence in an elderly community: a prediction analysis using a shortened NART. *British Journal of Clinical Psychology* (1990). 29, 83-90.
32. Nelson, H.E. A modified card sorting test sensitive to frontal lobe defects. *Cortex* (1976). 12(4), 313-324.
33. Burgess, P.W. & Shallice, T. The Hayling and Brixton Tests: Test manual (1997).Bury St Edmunds, UK. Thames Valley Test Company.
34. Pickering, R.M., Kunkel, D., Fitton, C., Ashburn, A., & Jenkinson, D. In-hospital recruitment to observational studies of stroke. *International Journal of Rehabilitation Research* (2010). 33(1):56-63

EXTENDED PAPER

1. EXTENDED BACKGROUND

1.1 Stroke epidemiology

Injury to the brain can result from several causes including perinatal disorder, brain tumour, infection, demyelinating disease, cerebrovascular disease (including stroke), trauma, epilepsy, and neurodegeneration (Cairns, 2004) as well as a consequence of medication and toxins (Powell, 2004). These injuries can result in various degrees of severity (including death) affecting a person's physical, emotional, cognitive, and/or behavioural functioning (Evans, 2003). A person who has suffered a stroke might experience problems in any or all of these areas, and a problem in one area can lead to difficulties in another, such as physical difficulties leading to a depressed mood. Consequently, stroke management and care should be a collaboration between professionals of various disciplines (Fawcus, 2000) and clinical psychology has a significant role to play in this interdisciplinary cooperation.

A stroke is caused by an interruption to the blood supply of the brain. This interruption can be caused either by an artery becoming blocked (thrombosis or embolism) and leading to tissue death (infarction) in the brain, which is known as an ischaemic stroke, or bleeding from an artery resulting in cell damage and death from the haemorrhage (Skilbeck, 1992). Bleeding into the brain tissue is called a intracerebral haemorrhage, and a bleed over the brain's surface a subarachnoid haemorrhage (Hankey, 2002). Approximately 90% of strokes are caused by infarction and 10% by haemorrhage (Celani *et al*, 1992), though it can be difficult to identify an accurate cause in approximately 20% of cases (Wolfe, 2000). The Oxford Community Stroke Project subdivided cerebral infarction into four types based on a combination of cause and site of the infarction: the categories are total anterior circulation syndrome (TACS), partial anterior circulation syndrome (PACS), posterior circulation syndrome (POCS) and lacunar circulation syndrome (LACS) (Bamford, Sandercock, Dennis, Burn & Warlow, 1991). Risk factors for stroke include age greater than 75 years, high blood pressure, atrial fibrillation, smoking and taking oral contraceptives (Wolfe, 2000). A transient ischaemic attack (TIA) initially presents as similar to a

stroke, though, as its name suggests, is short lived, with any symptoms (including cognitive impairment) improving within 24 hours (Skilbeck, 1992).

Stroke is a major cause of death and disability affecting up to 216 per 100,000 population in the UK each year (Mant, Wade, & Winner, 2004). In England there are currently more than 900,000 people living with the after effects of stroke, with approximately half of these dependent on others for help with activities of daily living (The National Collaborating Centre for Chronic Conditions, 2008). Incidents of stroke increase with age, with approximately half occurring in people aged over 75, and consequently the number of stroke patients will potentially continue to increase as a result of an increase in the longevity of the population (Hankey, 2002). Race and ethnicity appear to influence the incidence and prevalence of stroke, and geographical location the mortality rate, with mortality rates ranging from 249 deaths per 100000 population in Bulgaria to 27 per 100000 population in Switzerland (Hankey, 2002). Men and women appear to be affected equally (Hankey, 2002).

1.2 Cognitive Screening

Ideally, a cognitive screening test should be brief, and simple to administer and score by clinicians without specialist neuropsychological training (Blake *et al*, 2002). Brief screening tests for cognitive impairment may be useful for many differing purposes. Cullen, O'Neill, Evans, Coen and Lawlor (2006) cite several uses including aiding General Practitioner assessments, screening programmes of large scale communities, the identification of profiles of impairment specific to particular diagnoses, aiding differential diagnoses and identifying cognitive areas or patients for further assessment. Each of these uses will determine the design, content and scope of the screening tool, and given the plethora of screening tests available, it is important to match the test's output to the purpose of screening. This study is principally concerned with the diagnostic validity of the RBANS as a test to identify cognitive impairments following stroke that require further, detailed assessment. Detailed neuropsychological assessment has been highlighted as an important aspect of the management of stroke (Royal College of Physicians, 2008), though this can be costly, both in terms of finance and time, and effective screening can identify where these resources can be best utilised (Blake *et al*, 2002).

Lezak, Howieson and Loring (2004) point out that the use of any cognitive screening test should always be done with the limitations of the test being borne in mind. Even the best validated screening tests will not be able to identify every possible cognitive impairment nor every person with an impairment, unless it has 100% sensitivity. This in itself can be problematic in that in order to have such a high sensitivity rate the test is also likely include a high proportion of people who do not have an impairment. That is to say that with a very low cut-off rate, the test may have 100% sensitivity, but if all tests are positive it will have 0% specificity (though it will have included all people with the disorder) (Spitalnic, 2004). The same is true if reversed for specificity, in that it can be 100% specific by having a very high cut-off point, but will also excluded all those who do have the disorder. The best that can be concluded for a person who has no impairments identified is that they scored within normal limits at the particular time that the test was taken (Lezak, Howieson & Loring 2004).

1.3 Clinical Psychology and Stroke

Cognitive impairment following stroke is a predictor of poorer long-term functional outcome (Denti, Agosti & Francheschini, 2007) with at least 35% of stroke survivors having significant cognitive impairment at 6-month follow-up (Tatemichi, Desmond, Stern, Paik, Sano & Bagella, 1994). It is estimated that 75% of stroke survivors with cognitive impairment present with clinically significant mood disorders in the acute stage, as do 42% of stroke survivors without cognitive impairment (Saxena, 2006), with an estimated 35% of all stroke survivors presenting with depression following the acute stage (Hackett, Yapa, Parag & Anderson, 2005).

Evidence for psychological intervention following stroke is limited by a lack of high-quality research (Royal College of Physicians, 2008), and much of the support for their use with stroke survivors is extrapolated from research evidence for interventions for mood disorders within the general population (British Psychological Society [BPS], 2010). Watkins *et al* (2007), in a large randomised controlled study, reported that Motivational Interviewing led to a statistically significant improvement in mood following stroke, though it did not show an improvement in the functional recovery of stroke survivors. Cognitive Behavioural Therapy (CBT) has demonstrated mixed results in treating depression following stroke (Lincoln & Flannaghan, 2003) and more research is needed. There is even less research into psychotherapeutic interventions for post-stroke anxiety, though there is tentative evidence to suggest that CBT may be effective (Soo & Tate, 2007). Despite the lack of research evidence, psychological intervention has been identified as an important factor in helping people recover from stroke (BPS, 2010) and is recommended in the National Clinical Guidelines for Stroke (Royal College of Physicians, 2008). Equally, whilst there is little evidence to suggest that re-training of lost cognitive abilities is effective (BPS, 2010) compensation approaches have been shown to aid functional recovery and to help a person adjust to the consequences of a stroke (Lincoln, 2005), and the identification of cognitive impairment is an important

factor in planning for hospital discharge and in planning and delivering multi-disciplinary interventions (Royal College of Physicians, 2008).

The impact of a person having a stroke can be devastating for families and carers, with psychological problems and carer strain being commonly reported (Draper & Brockelhurst, 2007). Clinical psychologists can play an important role in supporting carers to support the survivor of a stroke, which can not only help to maintain the psychological well-being of the survivor (Morris, Robinson, Raphael & Bishop, 1991), but also reduces the financial burden on health and social service providers (Hirst, 2002).

The National Stroke Strategy (Department of Health, 2007) has made several service recommendations specifically pertaining to the provision of psychological services for survivors of stroke and their families:

“Screening (to) identify those who can benefit from access to a broad range of mental health and psychological services” (p43)

“Services need to develop long-term psychological and emotional support, with co-ordinated programmes starting with psychological support in hospital” (p43).

“Carers are also vulnerable to difficulties in coping and depression ...and...are entitled to an assessment in their own right” (p44).

From this document, the British Psychological Society (BPS, 2010) identified eleven quality markers where a clinical psychology could significantly contribute to post stroke survivor care. These were: Managing Risk (Quality Marker 2), Information advice and support (QM3), Assessment (QM8), Treatment (QM9), High quality specialist rehabilitation (QM10), End of life care (QM11), Long term care and support (QM13), Participation in community life (QM15), Return to work (QM16), Leadership and skills (QM18), and Research and audit (QM20). Within this context, screening for post stroke cognitive impairment plays a relatively small role in the possible contribution clinical psychologists could play

in providing psychological support for survivors of stroke, and in practice most screening would be performed by a member of the ward team (at the hospital where this current study was completed, screening for post stroke cognitive impairment was conducted by the ward Occupational Therapists). Where clinical psychologists do have a role in the screening of post stroke cognitive impairment is in the interpretation of the results. Screening, by its nature, compares a persons performance on the test against the performance of other people (either drawn from the general population or from a particular diagnostic group) to decide whether a person has scored at a significant point to conclude that an impairment is present, Clinical psychologists are equally interested in how that persons performance on the screening test compares with, and relates to, other aspects of that persons presentation. In isolation, a persons screening result is relatively meaningless, and for it to have any ecological value it should be embedded within a wider formulation that takes into account biological, psychological and social factors (Darby & Walsh, 2005). From this biopsychosocial formulation an understanding can begin to be developed of not only what the cognitive and functional consequences of having a stroke might be for an individual, but also an understanding of what the consequences might mean for the survivor and their families or carers. From this, interventions can be tailored to address the survivors idiosyncratic needs, which might include further neuropsychological testing to assess in greater detail the presence or otherwise of cognitive impairment, and may also include offering support and advice to the client, family or support team on managing or compensating for any identified impairments, as well as providing psychotherapeutic interventions for the survivor and/or their family in coming to terms with the stroke and its consequences and in treating post stroke depression or other related mood disorders.

1.4 Cognitive Domains

Cognitive domains have been variously described, but consensus appears to be to categorise them as domains of memory, language and communication, executive function, voluntary movement, visuospatial perception and attention, and number processing and calculation, each of which contain sub-categories (e.g. semantic and episodic memory). These domains are briefly described, along with their corresponding impairments.

Memory (from Evans, 2004) is not a unitary concept (either psychologically or anatomically), but variously sub categorised to including short term (or working) and long term memory, declarative (explicit, utilising conscious recollection) and non-declarative (implicit, such as priming and classical conditioning), semantic (context independent factual information) and episodic (context dependent, such as personal experiences), as well as a distinction being made between recall (recollection in the absence of the thing to be remembered) and recognition (material matched with a memory). Also, prospective memory refers to the ability to remember to do things in the future, which also involves co-ordinating planning and attentional abilities.

Any of these memory systems can become impaired, though disorders of short term and semantic memory are rare. With regard to memory impairment, a further distinction is made between anterograde memory (the learning of new information following the onset of impairment) and retrograde memory (memories laid down before the onset of impairment). The commonest memory disorder is amnesic syndrome where working, semantic, and implicit memories generally remain intact, whilst retrograde memory can be variably affected, and anterograde memories are impaired.

Language and communication (from McKenna, 2004) has been recently understood in terms of models of serial and hierarchical stages of information processing. A differentiation is made between comprehension and expression, with comprehension described as inputting into the semantic system, and

expression outputting from it. Distinctions are made (though similar models used) between visual and auditory communication, and non-verbal language.

Collectively known as aphasia, impairments include difficulty in using correct grammar and syntax, problems with aural and written comprehension, difficulty in articulation, and problems with word finding.

Executive function (from Burgess & Alderman, 2004) is described as the ability of a person to organise their ability to identify goals, and to follow and adapt plans to achieve them in the face of competing demands and circumstances.

Impairments are known as executive dysfunction and collectively as dysexecutive syndrome, of which there are many symptoms, with the commonest being difficulty in planning, distractibility, lack of insight, poor decision-making and social unconcern.

Voluntary movement (from Goldstein, 2004) is the ability to carry out purposeful and/or learned voluntary movement.

Impairment is known as apraxia, and is identified when a person is unable to perform such movements despite having normal motor skill and comprehension of what carrying out the movement involves. Apraxia is often sub-categorised into ideomotor apraxia (incorrect selection and sequencing of movements), ideokinetic apraxia (inability to coordinate fine and precise movements), and ideational apraxia (difficulty in using objects for their correct purpose despite being able to name the object)

Visuospatial perception (from Manly & Mattingley, 2004) refers to the structure of the visual system including the visual field and higher level visual processing.

Most commonly reported impairment of visuospatial ability is unilateral spatial neglect, which is defined as 'a difficulty in detecting, acting on or even thinking about information arising from the side of space opposite the damaged hemisphere' (p229). Also included are disorders of object recognition (agnosia).

Attention (from Manly & Mattingley, 2004) refers to the ability to concentrate and 'to stay on task', and whilst being difficult to operationalize and assess, are often reported as distractibility and absent-mindedness.

Number processing and calculation (from McNeil, 2004) refers to the ability to understand and manipulate numbers, including comprehension and production of written and spoken numbers both named and using numerals, and is considered a separate system to language, as patients with aphasia usually have preserved number processing and calculation abilities.

Number processing and calculation has received much less interest than other areas of cognitive impairment though it can have an enormous impact on everyday tasks such as managing money, using telephones, or knowing time and dates. It is not routinely assessed for by cognitive impairment screening tests (including the RBANS) and has received no apparent attention in the evaluation of these screening tests for post stroke impairments.

These cognitive domains are theoretically hypothesised concepts or constructs, the existence of which cannot be confirmed in any absolute way (Willmes, 2003). To be of any value (especially in terms of psychometric testing) these constructs should demonstrate acceptable *construct validity* (i.e. the extent to which the hypothesised implications of the theoretical construct are reflected in other research findings), and be adequately *operationalised* (essentially, how the construct is defined) (Barker, Pistrang, & Elliott, 2002).

Whilst most neuropsychological text books are focussed around the concept of cognitive domains (and often without commenting on their construct validity), not everyone agrees that these constructs are valid. Chaytor, Schmitter-Edgecombe & Burr (2006) for example, reported that four commonly used tests of executive functioning failed to predict participant's everyday executive functioning ability. This could of course be a reflection of the tests' lack of ecological (real life) validity, rather than a problem with the validity of the

construct of executive function. Though if, as the above description of construct validity suggests, construct validity derives at least in part from being able to measure hypothesised consequences of the construct, then it could be equally argued that the lack of validity lies with the construct itself rather than the tests. However, Lezak, Howieson and Loring (2004) concluded that questions regarding the validity of psychometric testing (and thus the validity of the theoretical constructs underpinning them) had been at least partially answered, 'almost always in the affirmative' (p11), by the body of research literature. Interestingly, Miller (1992) argued that construct validity is not an essential feature of psychometric tests when they are used for diagnostic purposes; the importance is to whether the test can reliably discriminate between the presence and type of impairment.

1.5 Cognitive Impairment and Stroke

Cognitive impairment refers to impaired functioning in aspects of one or more cognitive domains. Any cognitive impairment following stroke will depend on the site of the blockage or bleed and the extent of the resultant damage, and as the stroke can occur in any part of the brain, any (or even all) of the cognitive domains listed above can be affected with varying degrees of severity, and thus there is no common pattern of cognitive impairment following stroke (Skilbeck, 1992).

An injury to the brain may cause global cognitive impairment, in that there is a generalised impairment in cognitive functioning, or the impairment may be focal, affecting a discrete cognitive domain (Lezak, Howieson & Loring, 2004). In most cases, cognitive impairment following stroke is focal in nature due to an infarct affecting the local area: a haemorrhage stroke is less common and more like to cause global impairment (Hankey, 2002). There are several cognitive impairments that have become associated with stroke due to the regularity of their occurrence, of which Skilbeck (2003) suggests that aphasic problems and left sided neglect are the most common. However, a review of 3 recent research papers (Nys *et al*, 2005, Blake, McKinney, Treece, Lee, & Lincoln, 2002, and Catroni & Lincoln, 2005) suggests that overall, executive functioning was the most commonly identified cognitive impairment (when using a full battery of psychometric tests). The cognitive impairments identified in these studies by full battery neuropsychological testing are summarised below in table 4. It should be noted that these figures only represent patients well enough to participate and who gave their consent, and do not include figures for impairments of movement or calculation. Where separate tests have measured the same domain, it has not been possible to identify whether participants are included in both scores, so a range has been given (and note that this does not *necessarily* imply that there is a discrepancy in the construct validity, only that the tests measure differing aspects, or sub-categories, of the same cognitive domain).

| Cognitive Domain | Study | | |
|---|--------------------------------|-----------------------------------|------------------------------------|
| | Nys <i>et al</i> (2005) (N=34) | Blake <i>et al</i> (2002) (N=112) | Cartoni <i>et al</i> (2005) (N=30) |
| Executive Function | 32-47 | 52 | 86 |
| Perception | 21 | 26-51 | 60 |
| Memory | 12-15 | 42-56 | 46 |
| Language | 26 | 40 | 13 |
| Total % of those with at least 1 impairment | 70 | Not reported | Not reported |

Table 4. Summary of percentage of stroke patients identified with cognitive impairment by full battery neuropsychological testing.

As table 4 shows, there is a wide range of reported prevalence rates for cognitive impairments following stroke. This may be due to differences in samples sizes, research methodologies, and/or measures used in the full battery testing. Cartoni *et al* (2005) excluded patients with a diagnosis of aphasia, which would not only bias the prevalence rate for language impairment but may also have had an effect on the other battery results as the sample was made up from a potentially different population of stroke patients as reported by the other two studies. Likewise, neither Blake *et al* (2002) nor Nys *et al* (2005) reported on how they controlled for the effects of aphasia on the completion of tests for other cognitive domains (as a difficulty in understanding the test instructions could lead to spurious results unless understanding was ascertained).

There were also significant differences between the three studies in the duration between the occurrence of the stroke and the administration of the full battery testing. Blake *et al* (2002) reported that full battery testing was administered within three months of admission, Cartoni *et al* (2005) between one and eighty-

eight days (mean 20.73, SD 7.94) and Nys *et al* (2005) between two and fourteen days (mean 6.5, SD 2.9). Given that improvement is most rapid within the first three months following stroke (Hankey, 2002) this difference between testing time would potentially have a major impact on the impairments identified (and whilst Nys *et al* [2005] are critical of the Blake *et al* [2002] study for delaying testing, there may be advantages in testing later in that it is possible that these impairments are less likely to be effected by spontaneous remission, and hence are more important to identify in terms of prognosis and planning long term care).

A further difference between the Nys *et al* (2005), Cartoni and Lincoln (2005), and Blake *et al* (2002) studies that may have influenced their conclusions for cognitive impairment was the choice of tests used for the full battery neuropsychological testing. All three studies used extensive batteries, though Cartoni and Lincoln (2005) and Blake *et al* (2002) used a standard group of tests which were supplemented by alternative tests to further investigate any impairments identified: Nys *et al* (2005) used the same set of tests for each participant. Consequently, the Cartoni and Lincoln (2005) and Blake *et al* (2002) studies reported conclusions for cognitive impairment more akin to those in clinical practice whereas Nys *et al* (2005) reported more controlled results.

A final difference between the three studies is that the Nys *et al* (2005) study recruited a matched control group from which to compare the conclusions of the testing, whereas the Cartoni and Lincoln (2005) and Blake *et al* (2002) studies both used published normative data from which to draw their conclusions. As with the discussion above on the use or otherwise of a standardised battery, the Nys *et al* (2005) study has an advantage in that it is better controlled whereas the other two studies better reflect actual clinical practice.

It is interesting to note that whilst there is a wide variety in reported impairments (and bearing in mind that there is not a common pattern of impairment following stroke), language and communication difficulties have averaged as the least common impairment, yet receive substantial clinical input, at least when compared to that offered for other cognitive impairments (Royal College of

Physicians, 2008). This may be because communication and language is seen as a foundation to other work, because difficulty in communicating causes the patient significant distress or because rehabilitation and treatment processes are better defined and evaluated. Whatever the reason, there is potentially an argument that the remaining impairments are being somewhat under-researched or unacknowledged given their prevalence.

1.6 Diagnostic Validity, Sensitivity and Specificity

Diagnostic validity refers to a test's ability to accurately predict the presence or otherwise of an impairment. It has been argued that diagnostic validity only has relevance if it also demonstrates utility, in that the diagnostic category that the test is attempting to identify should have been shown to be a discrete entity with natural boundaries that separate it from other similar syndromes (Kendell & Jablinsky, 2003).

The diagnostic validity of a screening test can be ascertained by evaluation of its sensitivity and specificity. Sensitivity (the test's ability to identify all people with an impairment) and specificity (the test's ability to not include people without an impairment) can be measured by comparing the results of a test against those of other, well-established tests (tests with already established diagnostic validity). Therefore, if the number of people identified as being impaired by the screening test corresponds to the number identified as impaired by the established test, then the screening measure is highly sensitive. If they agree on those who are not impaired, then it is highly specific. In practice, there is a trade off between sensitivity and specificity, and acceptable rates are generally agreed to be 80% agreement or higher for sensitivity, and 60% or higher for specificity (Blake et al., 2002).

An extension of sensitivity and specificity calculations involves calculating Positive Predictive Values (PPV) and Negative Predictive Values (NPV). PPV refers to the number of people who have been correctly diagnosed by a particular test, and NPV to the number who have been correctly identified as not having the diagnosis by the test. The higher the percentage of PPV and NPV, the better the diagnostic accuracy of the test, with 50% indicating accuracy of no better than chance. Sensitivity, specificity, PPV and NPV are calculated by crosstabulation using the formula in table 5:

| | | TEST 1 (Gold Standard) | | |
|--------|-------|------------------------|----|-------|
| | | NCI | CI | Total |
| TEST 2 | NCI | a | | e |
| | CI | | c | f |
| | Total | b | d | |

Table 5: Calculation matrix for sensitivity and specificity, PPV and NPV.

Specificity % can be calculated: $a/b \times 100$

Sensitivity % can be calculated: $c/d \times 100$

PPV % can be calculated: $a/e \times 100$

NPV % can be calculated: $c/f \times 100$

The cut-off score on a test that gives optimal sensitivity and specificity can be calculated using Receiver Operating Characteristic (ROC) curves. ROC analysis compares the sensitivity and specificity of a test at differing cut-off points which are plotted to produce a curve. A test that has excellent diagnostic validity will produce a curve that reaches the top left hand corner of the graph. This can be analysed more formally by calculating the Area Under the Curve (AUC), which is considered equivalent to the Mann-Whitney U and Wilcoxon rank tests (Spitalnic, 2004). The AUC score ranges between 0.5 to 1.0, with 1.0 showing excellent diagnostic validity (sensitivity and specificity both 100%) and 0.5 being very poor (no better than chance).

1.7 Evaluation of Screening Tests for Post Stroke Cognitive Impairment

Though not part of the research procedure, the Sheffield Screening Test for Acquired Language Disorders (SST: Syder, Body, Parker & Boddy, 1993) was used to inform the inclusion / exclusion criteria regarding patients with aphasia. Whilst being a common and significant impairment following stroke (Hankey, 2002) there are virtually no cognitive tests that control for the affect of aphasia on the testing process, and thus the inclusion of these patients would strongly bias the results (Srikanth *et al*, 2003). The authors of the SST reported good inter-rater reliability and provided normative data for various age groups based on a relatively small sample size of mainly older adults. The SST was the standard screening test for aphasia at the research hospital site, and was administered as part of the routine intake assessments, meaning that ethical approval was not required for its use as a screening test for inclusion/exclusion criteria, and consequently its use for this purpose did not add to the participants testing load. A cut-off score of <15 was used to standardise the inclusion / exclusion criteria with other comparable research papers (Blake *et al*, 2002).

The MMSE was reported by Blake *et al*. (2002) to have good specificity (88%) and moderate sensitivity (62%) comparison for total score and overall conclusions for impairment following stroke (at a cut-off score of <24), but failed to find cut-off scores that would give adequate sensitivity or specificity in any specific cognitive domain. Nys *et al*. (2005) argued that the Blake study overestimated the sensitivity of the MMSE due to methodological problems (excessive differences in test intervals amongst participants). Their study concluded that a cut-off score of <24 only yielded sensitivity of 35% for cognitive impairment in acute stroke patients, and could not identify an optimal cut-off score. Further, the only cognitive domain that the MMSE showed any sensitivity to was verbal memory disorder (correctly identifying 4 out of 5 patients), and, with a cut-off score of <24 failed to identify: 11 out of 16 (69%) of patients with reasoning disturbances (using the domain categories outlined above, this would be classed as executive dysfunction); 64% with executive disorders; and 57% with visual perceptual impairments. They concluded that

reliance on the MMSE could result in a majority of post-stroke cognitively impaired patients not receiving correct rehabilitation and in being discharged without the impairments being correctly identified.

An evaluation of the Middlesex Elderly Assessment of Mental State (MEAMS; Golding, 1989 as cited in Cartoni & Lincoln, 2005) as a screen for post-stroke cognitive impairment reported only marginally better sensitivity than the MMSE. Cartoni and Lincoln (2005) reported good specificity (100%) but poor sensitivity (52%) comparison for total score and overall conclusions for impairment, using a cut-off of 3 or more fails. Sensitivity improved to 81% (with 50% specificity) when using 3 sub-tests to identify cognitive impairment in language, perception or memory. Sensitivity to executive functioning impairments was reported to be exceptionally poor at 11%.

A description of some of the methodological differences between the Blake *et al* (2002), Nys *et al* (2005) and Cartoni and Lincoln (2005) papers is presented in Extended Paper 1.4 – Cognitive Impairment and Stroke, and so will not be repeated here. What is worth noting though is that the Nys *et al* (2005) study only reported the percentage of participants misclassified as cognitively non-impaired, and Blake *et al* (2002) only reported the percentage figures for sensitivity and specificity: neither reported statistical significance or confidence intervals, and so it is difficult to draw conclusions from their results. Given the larger sample size of the Blake *et al* (2002) study, it is probable that greater statistical confidence can be given to these figures, though this would be conjecture and hard to estimate as they do not report their overall prevalence rate.

Cartoni and Lincoln (2005) did report confidence intervals for their conclusions of impairment following stroke on the MEAMS. On their conclusions for the MEAMS at a cut-off of 3 or more fails, they reported sensitivity of 52% with a 95% CI of 32-71%, and specificity of 100% with a 95% CI of 29-100%. On their conclusions for 5 or more fails, sensitivity was reported at 26% with a 95% CI of 11-46%, and specificity of 100% with a 95% CI of 29-100%. Therefore, it can only be concluded with any confidence that the MEAMS was not a sensitive test

as the 95% confidence intervals did not reach 80%. However, the confidence in these results has to be tempered by the non reporting of the overall prevalence rate in this study (as it may be testing an unrepresentative sample).

More recently, the Addenbrooke's Cognitive Examination Revised (ACE-R; Mathuranath et al., 2000 as cited in Mioshi, Dawson, Mitchell, Arnold and Hodges, 2006) was proposed as an alternative to the MMSE as a potential screening tool for post-stroke cognitive impairment, after demonstrating good sensitivity (94%) and specificity (89%) for dementia (Mioshi et al., 2006). However, the results from a recent, and as yet unpublished, doctoral thesis, suggest that the ACE-R is a poor predictor of post-stroke cognitive impairment (sensitivity 77%, specificity 44%) (Lincoln, 2008), especially with regard to executive function and perception (N. Lincoln, personal communication, 15th December, 2008).

A possible reason as to why these tests performed so poorly in identifying post stroke cognitive impairment could be due to the development of the tests to measure cognitive impairment in patients with dementia. Dementia literature often highlights memory impairments, as these are usually the earliest signs of a potential disorder (Morris & Kopelman, 1992). However, as discussed in above (Extended Paper 1.4 – Cognitive impairment and Stroke) executive dysfunction and visuospatial perceptual/attentional difficulties appear to be as, if not more, common following stroke. It could be possible that these tests would therefore be sensitive and specific for cognitive impairment with dementia, as impairments of executive dysfunction and visuospatial perceptual/attentional difficulties would be rather more rare and thus not show up in evaluation as a false negative (and if it were not fully measuring these impairments, as seems likely given the literature outlined above, would not show false positives). This appears to be supported by Srikanth *et al* (2006) who reported that a combination of the MMSE and the Informant Questionnaire for Cognitive Decline in the Elderly (IQCODE) failed to identify post stroke cognitive impairment, though were better at identifying post stroke dementia.

1.8 Detailed Description of RBANS

The RBANS comprises of 12 sub-tests that are combined to form 5 index scores and a total score. The indexes (and sub-tests) are:

Immediate Memory (List Learning, Story Memory)

Visuospatial/Constructional (Figure Copy, Line Orientation);

Language (Picture Naming, Semantic Fluency);

Attention (Digit Span, Coding)

Delayed Memory (List Recall, List Recognition, Story Recall, Figure Recall).

The RBANS does not have an index for executive function.

Total score and index scores are reported as a standard score with a mean of 100 and a standard deviation of 15, which are adjusted for age and education to allow comparison across groups. The test has a Form A and Form B, to allow for assessment of progression of impairment or to evaluate the outcome of clinical trials, which have good test – retest reliability (correlation coefficient of 0.84 for people with schizophrenia, 0.77 for controls, Wilks et al., 2002), despite only a small proportion (N=100) of the original standardization sample receiving Form B, and good split-half reliability ranging from 0.80 to 0.94 (Randolf, 1998).

The normative scores appear to have been adequately validated, based on a sample of 540 individuals aged between 20 to 89 years, considered to be representative of the U.S. population using a census match (Randolf, 1998). Normative data for the individual test scores was not included in the test manual, but has been made available through Lezak, Howieson, & Loring (2004). A criticism of the normative data is that there is little range for younger normals in several sub-tests (picture naming, word list recognition, and figure copy) and thus a small effect on the sub-test can lead to a larger change in the index score (Randolf, 1998).

Several studies have provided supporting evidence for the use of the RBANS in screening for cognitive impairment in dementia. Duff et al., (2008) reported that when cut-off scores of between one and one and a half standard deviations below the mean were applied, the RBANS demonstrated excellent diagnostic accuracy, especially with regard to Immediate and Delayed Memory index scores (area under ROC curve 0.96 and 0.98 respectively, where 1.00 is the highest possible), in patients with Alzheimer's disease. However, as mentioned previously, evaluating a test for its validity against a dementia population does not mean that it is adequately testing for impairments of executive dysfunction and visuospatial/constructional difficulties.

There is evidence that the RBANS has demonstrated good validity in screening for some cognitive impairments with heterogeneous groups as well as with differing specific populations. Gold, Queern, Ianhonem & Buchanan (1999) reported that the RBANS correlated well with several cognitive domains in a small sample of schizophrenic patients, but did not correlate with language difficulties (though the study did not examine executive dysfunction and had a small sample size). In a follow-up study, Hobart, Goldberg, Bartko, and Gold (1999) compared the RBANS to full battery tests results from a larger sample (n=150) of diagnostically heterogeneous psychiatric outpatients. This paper concluded that the RBANS correlated well with some domains (notably attention and visual memory) but performed poorly at identifying executive difficulties. A minor criticism of this paper is that despite having a diagnostically heterogeneous group, the sample was limited to African Americans who were described as poorly educated and economically disadvantaged, and with high levels of substance co-morbidity; it would therefore be difficult to generalize these findings (though Patton et al, 2003, reported that differences between older African American and Caucasian subjects tests score were similar in difference on the RBANS as with other psychometric tests) . A more pertinent criticism would be that the full battery testing was somewhat limited in scope, and that there was only one measure for executive function, Wisconsin Card Sorting Test, which may have disadvantaged any participants with visuospatial impairment. Equally, there are several sub-domains of executive functioning,

and it cannot be concluded that a failure to correlate to one means that the RBANS does not identify executive dysfunction.

Several other studies that have provided supportive evidence for the use of RBANS as a screening test for cognitive impairment, though these have tended to focus on assessing the RBANS as a measure of overall cognitive impairment, rather than using it to identify impairment in particular domains. The populations for which the RBANS has been evaluated include; psychotic adolescents (Holtzer et al., 2007); multiple sclerosis (Beatty, 2004); traumatic brain injury (McKay, Wertheimer, Fichtenberg, and Casey, 2008); and end-stage liver disease (Sorrell, Zolnikov, Sharma, and Jinnai, 2006). Additionally, there is some supportive evidence for the ecological validity of the RBANS, with Terryberry-Spohr, Gordon, & List Kalins (2000) concluding that the RBANS predicted functional outcome (as measured by the Functional Independence Measure (FIM)) equally as well as lengthier neuropsychological batteries (though of course this does not mean that neuropsychological tests predict functional outcome) in a heterogeneous sample of 118 psychiatric in-patients. This finding was supported by Bennett (2006) who concluded that the RBANS total score, and especially the index scores of Attention, Immediate Memory, and Visuospatial abilities, predicted functional abilities in dementia patients.

1.9 Studies Relating to RBANS and Stroke

Support for the ecological validity of the RBANS index scores in stroke patients has been reported by Larson et al (2003). In a 6-month follow-up study of 34 inpatient stroke patients, they found that: multiple regression of initial visuospatial/constructional, delayed memory, and attention indexes predicted 46% of the variance of the cognitive measure of the FIM at follow-up (with delayed memory also making a significant individual prediction ($r=0.61$, $p<0.002$)); the same three indexes predicted 22% of the Motor (measuring functional activities) FIM variance (visuospatial/constructional index correlated $r=0.46$, $p<0.01$); 14% of frequency of activity (visuospatial/constructional $r=0.46$, $p<0.01$); 17% of life satisfaction (language $r=-0.47$, $p<0.01$); and 21% of physical disability (visuospatial/constructional $r=0.46$, $p<0.01$).

These findings are consistent with those reported by Terryberry-Spohr et al (2000) mentioned above, and those of Hoyer et al (2000) in a study of stroke patients undergoing inpatient rehabilitation, which also suggested that the RBANS could differentiate the hemispheric side of the stroke. Combined, these studies would indicate that the RBANS demonstrates reasonable ecological validity for stroke patients, and is especially strong at predicting cognitive impairment. A limitation of the Larson (2003) study, that only a small proportion of patients could be contacted for follow-up, is probably compensated for by the reliability of these findings across the three studies.

In a carefully controlled study of a large sample of in-patient stroke patients, Wilde (2006) found intercorrelations between RBANS index scores similar to those reported by Randolph (1998), but factor analysis did not support the 5 indexes purporting to measure the cognitive domains. Instead, the results suggested a 2 factor solution of visuospatial/visual memory and language/verbal memory factors. The latter of these factors strongly correlated with an independent measure of language and executive function ($r=0.65$, $p<0.001$) as did the former at a slightly weaker level ($r=0.30$, $p=0.04$). Measures of neglect and visuospatial impairment were also significantly correlated, though no correlation was found between the RBANS and measures of receptive

language. It is interesting to note therefore that the RBANS is a potentially valid measure of executive dysfunction in stroke patients, despite not having this as an index score.

Finally, Duff, Beglinger, Kettmann, & Bayless (2006) reported a single case study of a 22 year old psychiatric patient who suffered a stroke following screening with the RBANS. This paper suggested that the RBANS demonstrated sensitivity to pre and post stroke cognitive impairment variations (despite the patient having pre-existing cognitive impairments), and being especially sensitive on the visuospatial/constructional index. The RBANS also demonstrated stability on sub-tests where cognitive impairment was not identified by full battery testing. Whilst not generalisable to the larger stroke population, and many potentially confounding variables could not be controlled, this paper appears to add support to some of the findings detailed above.

1.10 Research Aims

A further additional aim of this research project initially was to compare the RBANS conclusions for sensitivity and specificity with those of the MMSE, to ascertain which had the better diagnostic validity. This was an original aim due to the common usage of the MMSE as a global screening test for cognitive impairment (Nys et al, 2005) and its continued use specifically as a screening test for post stroke cognitive impairment. Several studies (e.g. Nys et al, 2005, Cartoni & Lincoln, 2005) have concluded that the use of the MMSE for this task is not appropriate.

Ethical approval was not sought to administer the MMSE for this study as it was already in use as a routine screening test on the stroke wards identified (ethical approval was sought to gather this data from the medical notes). However, by the time that this study had been granted ethical approval, the stroke wards had begun to replace the use of the MMSE with the Montreal Cognitive Assessment (MoCA: Nasreddine, 2004). Consequently there was little data that could be collected on the MMSE, and by the time the study came to be written up, not enough had been collected to be appropriately included in the study. Approval was not sought to administer the MMSE separately, firstly because the testing load on participants of the study was already high (and thus it did not seem appropriate to add the MMSE to either the RBANS or full battery testing) and secondly, administering the MMSE separately to the other testing would have involved identifying a further research assistant, and this did not appear to be likely to happen.

A final aim of the study was to establish whether an extended study into the sensitivity and specificity of the RBANS as a screening test for post stroke cognitive impairment was justified and feasible. The justification for an extended study would be centred on the results of this pilot in terms of whether acceptable levels of sensitivity and specificity could be reasonably predicted, based on a sample size comparable to previously published research (e.g. Cartoni & Lincoln, 2005, Nys *et al*, 2005). The feasibility of an extended study was concerned with prevalence rates identified within the pilot for global and

domain specific cognitive impairments, and the implication of these on estimated sample size. The pilot would also provide information as to expected recruitment rates, estimated staff time, time scales, and in identifying any unforeseen obstacle. Equally, the pilot would provide an opportunity to evaluate the utility of the neuropsychological test battery.

2. EXTENDED METHODS

2.1 Sample Size

The initial sample size for this study was arrived at based on research experience, clinical expertise and previous studies using the same design to report sensitivity and specificity of post stroke cognitive impairment screening tests. This suggested that in order to be meaningful the sample should be large enough to ensure that there is a minimum of 10 participants in each condition (cognitively impaired and non-cognitively impaired) (N. Lincoln, personal communication, 16th January, 2009). According to a study by Nys et al. (2005), “70% of stroke patients were impaired in at least 1 cognitive domain” (p627). Therefore, in order to ensure 10 participants in the non-cognitively impaired category, a minimum of 30 participants were required (i.e. 30 participants x 30%[non-impaired] = 10 participants in the non-cognitively impaired category). This number was comparable with other similar studies (e.g. Cartoni & Lincoln, 2005, Nys *et al*, 2005). Due to the nature of acute stroke wards, where patients are often moved at short notice (for instance discharged from care or as a result of complications), a relatively high drop out rate was expected for this study (for instance, Cartoni & Lincoln, 2005, had 7 out of 37 participants drop out), which suggested that 40 patients should be recruited as participants to arrive at a sample size of 30.

This sample size was challenged during the ethical approval process. Buderer (1996) reported that studies evaluating the diagnostic validity of a test frequently overlooked the importance of statistical issues in estimating the required sample size, relying instead on factors such as previous research sample sizes, cost, past experience and convenience. Whilst acknowledging that these are important factors, Buderer (1996) also argued that too small a sample size could result in imprecise estimates of sensitivity and specificity, as well as potentially resulting in misleading results if the sample does not reflect the prevalence of the disorder in the target population. Buderer (1996) provided statistical methods to calculate an acceptable sample size based on the

“clinically acceptable degree of precision, the hypothesised value of sensitivity and specificity and estimated prevalence of the disease” (p895).

Estimates of prevalence rates of global and domain specific post stroke cognitive impairment vary (see table 3), and this has implications in calculating the sample size for a study of this type. Equally, the cutting points of >80 and >60 for adequate sensitivity and specificity respectively are well established; what is unknown are the expected sensitivity and specificity rates of the RBANS. However, an educated estimation of these rates are needed to complete a sample size calculation, and at present these are unknown. The current pilot study was planned with a sample of 40 participants which would be comparable to previously published research paper as described above, and would allow an estimate of the prevalence rates of global and domain specific cognitive impairment to be identified, as well as providing information regarding the expected sensitivity and specificity rates, and would thus provide information that could be used to calculate a sample size that would provide results within an acceptable confidence interval. This information would then be used to inform an extended study if the pilot results suggested that this was justified and feasible. The Burdener (1996) calculation for sample size estimation is detailed as:

Specifications:

Specify the maximum clinically acceptable width of the 95% CI. Call it **W**.

Specify an estimate for the prevalence of disease in the target population. Call it **P**.

Specify a value for the expected sensitivity of the new diagnostic test. Call it **SN**.

Specify a value for the expected specificity of the new diagnostic test. Call it **SP**.

(For purposes of calculations, W, P, SN, and SP are expressed as numbers between 0 and 1, rather than as percentages.)

Calculate the Number with Disease, TP + FN:

Calculate the Sample Size Required for Sensitivity, $N1$:

$$N1 = \frac{TP+FN}{P}$$

Calculate the Number without Disease, FP +TN:

Calculate the Sample Size Required for Specificity, $N2$:

$$N2 = \frac{FP+TN}{(1 - P)}$$

The estimated sample size is whichever is the greater of $N1$ or $N2$

2.2 Consent

Capacity to give informed consent to participate in the study was ascertained in two ways. Firstly through consultation with the healthcare team, including reference to the routine intake assessments, and secondly, after discussing possible participation with a member of the research team, the research team member asking the potential participant to repeat back their understanding of what participation in the study would involve. If the potential participant was unable to demonstrate an understanding of the process of involvement in the study then they were not recruited for the study. If capacity to give informed consent was evident, then the potential participant was asked to participate, and if they agreed to do so, signed a consent form.

2.3 Test Cut-Off Points

Cognitive impairment for conclusions of cognitive impairment on the neuropsychological test battery was defined as scoring below the 5th percentile for age-adjusted norms on each of the battery tests. In clinical practice such a cut-off score would be arbitrary and a decision about the presence of a cognitive impairment or otherwise would be taken with reference to the wider clinical picture. To some extent the cut off score on a diagnostic validity study, where the boundaries are blurred between impairment and non impairment, is also arbitrary, as what is being examined is the extent to which a score on one test agrees with the score on another. A score with a specified SD below the pre-morbid estimate could have been used, though accurately defining the pre-morbid estimate can be problematic, and this still leaves the problem of how many points below the SD to chose, as 1SD may result in false positive results, and 2 SD in false negatives (Lezak *et al*, 2004). The decision to use below the 5th percentile was based on clinical and research experience (N. Lincoln, personal communication, 16th January, 2009), and on convention the that a cut-off score, in the absence of other methods of differentiating impairment from non impairment, can be expected to be reasonably accurate if it compares to the lowest score made by 95% of the normative sample (Lezak *et al*, 2004). This also has the advantage of not being based on individual differences, instead expecting an overall reduction to the mean, as well as making comparison with similar studies easier.

The cut-off score for identifying cognitive impairment on the RBANS was taken from the RBANS manual (Randolph, 1998) as being 69 or below on the Total Scale and Index scores. This cut-off represents the lowest 2% of scores from the normative data. In a study of cognitive impairment in people with dementia, Duff *et al* (2008) reported excellent diagnostic validity for the RBANS when cut-off point of between 1 and 1 ½ SD below the mean were used. This was applied to the RBANS cut-off points for subtest scores in this study as standard scores are not available for these.

Cut-off scores are a major feature of screening tests and intrinsic to the evaluation of the diagnostic validity of a test. However, Cullen, O'Niell, Evans, Coen and Lawlor (2007) point out that a reliance on a single piece of data runs counter to most clinicians approach to diagnoses, which is based on the testing of various hypotheses, taking into account various factors including qualitative information not provided by a single score. Whilst this is a very valid comment, it is less applicable to this study, as the research being undertaken here does not in any way suggest that screening for post stroke cognitive impairment should replace or substitute professional neuropsychological investigation, more that it can aid in directing these investigations towards those most likely in need of them.

2.4 Neuropsychological Test Battery

The battery tests were selected to identify global cognitive impairment and a broad range of investigation, as well impairment within the specific cognitive domains of interest in the study. A test battery created in this way has the advantage of meeting the criteria required for this study, though has the disadvantage of not being subjected to a large scale standardisation study (Lezak *et al*, 2004). However, the tests were chosen due to their good levels of reported reliability and validity (including standardisation and normative data), their common usage in neuropsychological testing, and the relative brevity of their administration (thus not subjecting the participants to unnecessarily lengthy testing).

For Immediate and Delayed Memory the Rey Complex Figure (Meyers & Meyers, 1995) and selected sub-tests of the Wechsler Memory Scale third edition (WMS III: Wechsler, 1997a) were chosen. The Rey Complex Figure is a well established and widely used test with good psychometric properties, and has demonstrated good sensitivity to even mild cognitive impairment across a wide range of disorders (Lezak *et al*, 2004). The WMS III memory test battery is widely used and well established, with good overall reliability, though several of the individual sub-tests have limited reliability and validity, especially Faces I and II (Lezak *et al*, 2004). However, the Logical Memory sub-tests have demonstrated good reliability when compared to other similar tests and appear to demonstrate ecological validity (Lezak *et al*, 2004).

The WMS III sub-tests of Digit Span and Letter/Number Sequencing were selected to assess Attention, again due to the WMS III reporting relatively good levels of reliability and validity (Wechsler, 1997a). These sub-tests are also included in the WAIS III battery (Wechsler, 1997b) and as such have been exposed to further extensive evaluation.

As well as being included for Immediate and Delayed Memory, the Rey Complex Figure is initially copied to assess for Visuospatial impairment. Visuospatial impairment was also assessed by the Behavioural Inattention Test

(BIT) Star Cancellation (Wilson, Cockburn & Halligan, 1987) sub-test which has demonstrated good correlation with other tests of visual inattention as well as showing good sensitivity to impairment within various disorders (Lezak *et al*, 2004). The Visual Object and Space Perception Test (VOSP: Warrington & James, 1991) was also administered as part of the test battery to assess for Visuospatial impairment, again due to its extensive use and generally well reported psychometric properties (Lezak *et al*, 2004), though reliability of the Position Discrimination sub-test was reported as poor by Bonello, Rapport & Millis (1997).

The short NART (Beardsall & Brayne, 1990) was used to assess pre-morbid intelligence. The NART itself has well established psychometric properties (Lezak *et al*, 2004). Beardsall & Brayne (1990) reported that the predictions of the short NART were very highly correlated with the full NART scores, thus providing a shorter, and consequently less taxing, test of pre-morbid intelligence estimate.

Executive Functioning was assessed by the Modified Card Sorting Test (MCST: Nelson, 1976) and Brixton Spatial Anticipation sub-test of the Hayling and Brixton test (Burgess & Shallice, 1997). The MCST is a modified version of the Wisconsin Card Sorting Test, a test that had been shown to be reliable in identifying brain lesions in people with suspected brain damage (Milner, 1963, as cited in Nelson, 1976). The MCST uses half the number of cards as the WCST and has slightly different administration rules, making it easier for testees to tolerate (and with reference to this study, completing the full WCST would have added to great a testing burden to the full battery, both in terms of duration and potential for fatigue). Nelson (1976) reported the MCST to be a good predictor of frontal lobe lesions, and the test has subsequently demonstrated good levels of reliability and validity (Lezak *et al*, 2004). The Brixton Spatial Anticipation Test also demonstrated reliability in discriminating frontal lobe lesions (Burgess & Shallice, 1997) though has been criticised for placing a heavy demand on working memory (Lezak *et al*, 2004).

Executive function was also assessed by the Controlled Word Association Test (COWAT: Benton & Hamsher, 1989) FAS test. The COWAT: FAS is a well established test of language impairment and one of the few tests of verbal fluency to have extensive normative data (Tombaugh, Kozak & Rees, 1999). The FAS has also been shown to be particularly sensitive to severity and location of stroke (Spreen & Benton, 1977). The COWAT: FAS was chosen for inclusion in the full test battery to provide an alternative measure of executive function impairment for those participants with visual neglect who would not be able to reliably complete the Brixton test and MCST.

There are a myriad of alternative tests that could have been chosen for the test battery in place of those selected, and the ones listed have been influenced by factors such as availability and clinical preference/experience as well as for the more formal reasons outlined above. Alternative tests that were considered included the more recent WMS (WMS IV: Wechsler, 2010), though this was not included firstly due to the pragmatic consideration of cost, and secondly due to the fact that it does not contain the Logical Memory sub-tests and would have potentially necessitated the completion of the full test (thus lengthening the testing process). The WMS IV does however claim enhanced clinical utility as well as extended normative data (Wechsler, 2010). The Rey Auditory Verbal Learning Test has demonstrated good psychometric properties (Strauss, Sherman & Spreen, 2006) and was considered as a measure of immediate and delayed memory, though the test appears to lack the ecological validity of the WMS III Logical Memory tests, as well as requiring a relatively high functioning level to complete. The Trail Making Test (TMT) is frequently included in neuropsychological tests batteries and has been shown to be sensitive to a wide range of cognitive impairments (Reitan & Wolfson, 1985). However, whilst the TMT is a good indicator of global cognitive impairment, there is debate as to which particular domains it measures (Lezak *et al*, 2004), and this would have made its inclusion in the test battery for this study problematic in terms of comparing it to the specific components of the RBANS being investigated.

2.5 Details of Research Procedure

If patients were considered as suitable for inclusion in the study, they were initially approached by a member of healthcare team to participate and introduced to a member of the research team (either the chief investigator or the research assistant) and given the patient information sheet. The potential participant was encouraged to discuss potential participation with family, carers, healthcare staff and researchers. The researcher then recorded on a record sheet that the Participant Information sheet had been given. Potential participants were informed that they were under no obligation to participate, and that not participating would in no way affect the care provided. The patient was then approached by a member of the research team after having had a minimum of 48 hours to decide. If the patient had decided to participate, the information sheet was discussed, any questions answered, the patients understanding of the study ascertained, and informed consent taken by signing the consent form. If capacity to give informed consent could not be ascertained, the patient was informed that their involvement would be discussed with the healthcare team to decide whether it would be in their best interest to participate.

After giving informed consent the participant then completed either the RBANS (with the research assistant) or the full battery tests (with the chief investigator). Alternating between initial administration of the two sets of tests was achieved through reference to the record sheet, with either the RBANS or full battery testing being allocated on an opportunity basis. The Chief Investigator and assistant psychologist regularly reviewed the record sheet to see who had been given the Participant Information Sheet and who were thus waiting to be approached regarding participation, as well as to review who had completed the initial set of tests. Whilst the participants had been informed that the second testing would take place within a maximum of 2 weeks, in practice it generally occurred within the same week. The participant was then administered the alternate set of tests i.e. the full battery, administered by the chief investigator, or the RBANS, administered by the research assistant.

The RBANS and full battery tests were administered according to the individual manual instructions. The initial testing was scored and the record sheet completed listing the Participant ID number, the date consent was taken, and the date of completion of the first testing. The ID number was allocated in order that consent was taken. The consent form was then filed in the healthcare notes and the completed tests in a box file locked in a secured filing cabinet on the ward. The alternative test was recorded and filed using the same process. The organization and day-to-day management of the study (including liaising with the ward staff teams) was the responsibility of the Chief Investigator. The research procedure is summarised below in Figure 1.

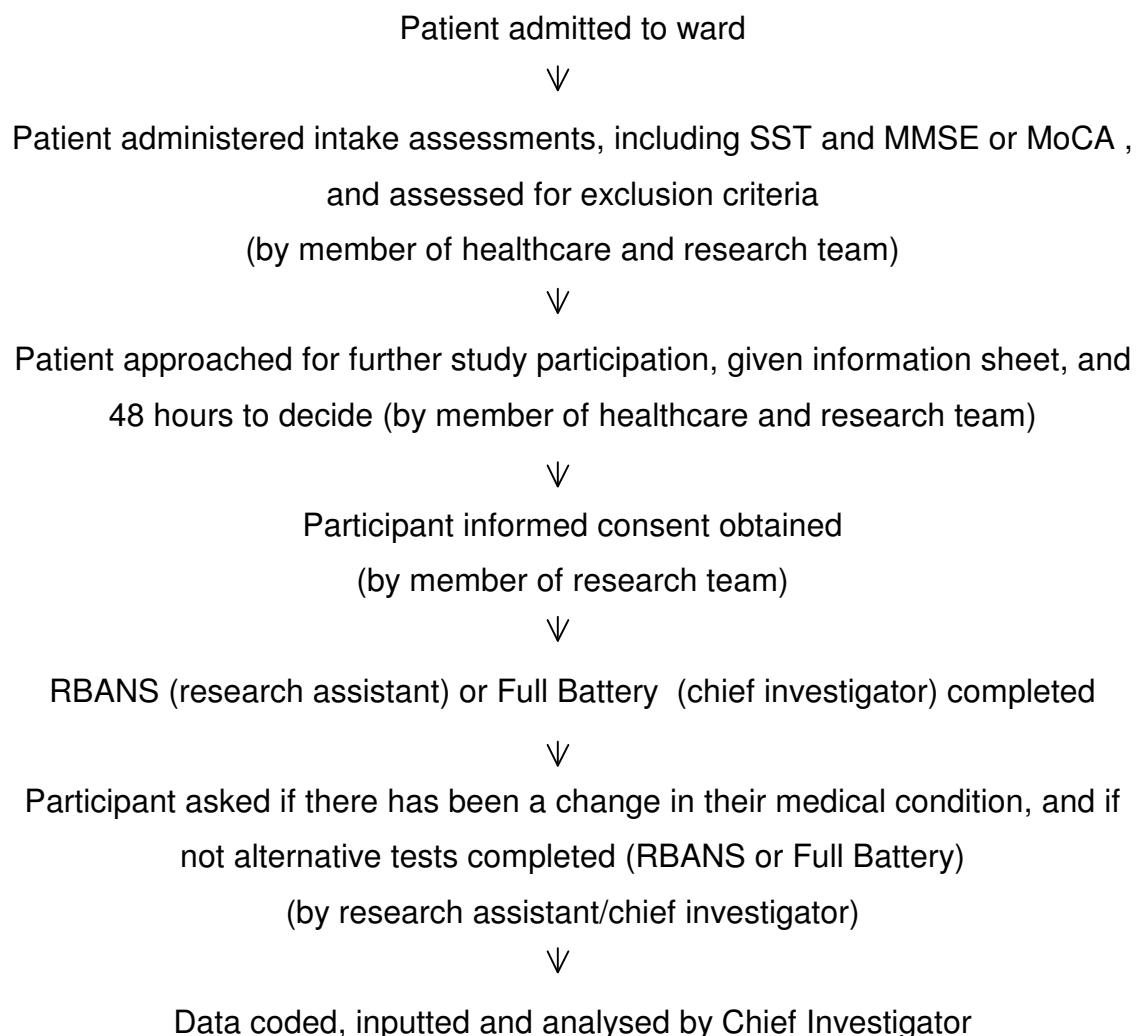


Figure 1. Flowchart of the research procedure

2.6 Ethical Approval

The main ethical considerations identified before submission for ethical approval were assessing capacity to give informed consent, the estimation of an adequate sample size (to allow for generalisability of the results, and thus not subjecting participants to extensive testing without generating useable data) and the possible detrimental effect of lengthy neuropsychological testing on unwell participants.

Capacity to give informed consent was guided by good clinical practice guidelines and relevant local trust policies and procedures, and took into account the need for this to be informed at an MDT level. The sample size was determined by estimates of the prevalence of cognitive impairment in the proposed population, and based on previously published research. The detrimental effects of lengthy neuropsychological testing were addressed by choosing appropriate tests that were relatively quick to administer, as well as ensuring that the participants were aware beforehand of the duration of the testing and allowing breaks when needed. A further ethical consideration concerned whether to reveal the results of the testing to the participants, as this could be seen as an inducement to participate or detrimental to non-participants. However, after discussion with the Research Ethics Committee (REC) it was decided that the test results should be made available to participants and their carers (with the participants consent). Other ethical issues included maintaining participant confidentiality and data storage. Participant confidentiality was achieved by the use of anonymised study ID numbers, and data storage concerns were addressed by ensuring that all the test score sheets were kept in a secured file on the ward for the duration of the study. Information that was taken off the ward for the purpose of this study (namely the test result scores and basic demographic information) were kept electronically on a password encrypted memory stick, and were backed up on the password-protected network on the University of Lincoln computer system. After the completion of the study the test sheets were securely stored at the University of Lincoln, and will be securely destroyed after 7 years.

The Research Ethics Committee highlighted several further issues as ethical concerns. The most pertinent of these were restricting the age of participants to those covered by the normative data samples identified in the published manuals for the full battery neuropsychological tests, and the need for a formal sample size calculation to be performed. Ethical approval was sought to complete the study across two sites to allow for access to a larger number of potential participants and the REC requested that both sites followed the same methodological procedure. However, a research assistant could not be identified to complete the RBANS testing at one of the sites meaning that the study could not be conducted there (as the chief investigator could not administer both the full battery and RBANS as he had to be blind to one set of tests to control against researcher bias). All requests for amendments to the study were complied with, and the details of these (and the other issues highlighted by the REC) are provided in Appendix B. The impact of these amendments on the study are discussed in Extended Paper 4.2.

3. EXTENDED RESULTS

3.1 Normality of Distribution

Analysis of the demographic variables of the recruited sample was performed to test for normality of distribution. As the sample size was less than 50 ($n=40 < 50$), the Shapiro-Wilks test was used, where $p > 0.05$ indicates normal distribution. Analysis showed that Age, Gender and Years of Education were not normally distributed (Age: $W(40) = 0.81$, $p < 0.001$, Gender: $W(40) = 0.62$, $p < 0.001$, Years of Education: $W(40) = 0.78$, $p < 0.001$). The Interval Between Testing was not normally distributed ($W(40) = 0.71$, $p < 0.001$), and neither was time from admission to final testing ($W(40) = 0.87$, $p < 0.005$). The RBANS Total Scale score was normally distributed ($W(40) = 0.96$, $p > 0.1$), as were the RBANS Immediate Memory scale ($W(40) = 0.95$, $p > 0.05$), the Attention scale ($W(40) = 0.97$, $p > 0.4$) and the Delayed Memory scale ($W(40) = 0.96$, $p > 0.1$). The RBANS Visuospatial/Constructional and Language scales were not normally distributed ($W(40) = 0.92$, $p < 0.01$, and $W(40) = 0.90$, $p < 0.005$ respectively).

3.2 Demographic Details

No demographic details were recorded for patients who did not consent to participate. Consequently no analysis could be done to explore demographic differences between participants and non-participants.

Analysis of the relationship between the RBANS Total Scale score and demographic information showed that there was no statistically significant relationship between RBANS Total Scale score and Age ($r(40) = -0.29$, $p > 0.05$) or gender ($t(40) = 1.13$, $p > 0.1$), though there was a statistically significant relationship between the Total Scale score and years of education: $r(40) = 0.63$, $p < 0.001$.

Analysis of difference between participants identified as cognitively impaired and non-impaired by the full battery of neuropsychological tests showed that there was no statistically significant difference identified by age: $U = 74$, $p > 0.1$, and that there was a statistically significant difference according to years of education: $U = 30$, $p < 0.001$. Analysis also showed that gender was a statistically significant predictor of classification of impairment: Chi-square = 5.09, $p > 0.05$, with no females identified within the non-cognitively impaired category.

3.3 Descriptive Details

Details of the mean scores on the RBANS indexes and individual full battery tests, together with conclusions for cognitive impairment, are presented below in table 6. The conclusions for RBANS cognitive impairment are based on the manual suggested cut-off score of 69, with the conclusions for the individual tests comprising the full battery being based on the 5th percentile cut-off point (unless using the manual based cut-off point for tests such as the VOSP, as detailed previously), Note that not all participants completed every test on the full battery. This was due to several factors: firstly, if a participant was unable to complete a test due to an impairment identified in a separate cognitive domain (e.g. visual neglect making completion of the MCST invalid) and secondly, if a score on an earlier administered test indicated impairment in that domain thus making continued testing of that domain redundant and unnecessarily adding to the participant's testing load.

Table 6. Descriptive details from the RBANS and full battery testing.

| <i>Assessment</i> | <i>n</i> | <i>Mean</i> | <i>SD</i> | <i>Range</i> | <i>n impaired (%)</i> |
|---------------------------|----------|-------------|-----------|--------------|-----------------------|
| <i>RBANS</i> | | | | | |
| Immediate Memory | 40 | 81.87 | 23.13 | 40 – 123 | 14 (35%) |
| Visuospatial/construction | 40 | 77.32 | 24.97 | 40 – 131 | 20 (50%) |
| Language | 40 | 85.70 | 17.67 | 40 – 117 | 6 (15%) |
| Attention | 40 | 77.75 | 18.54 | 46 – 128 | 16 (40%) |
| Delayed Memory | 40 | 77.47 | 22.72 | 40 – 119 | 16 (40%) |
| Total Scale | 40 | 75.73 | 20.48 | 44 – 121 | 17 (43%) |
| <i>Full Battery</i> | | | | | |
| Logical Memory I | 40 | 28.08 | 12.89 | 3-47 | 10 (25%) |
| Rey Copy | 34 | 11.26 | 13.53 | 0 – 34 | 20(59%) |
| Digit Span | 40 | 14 | 4.88 | 7 – 27 | 6 (15%) |
| Rey Immediate Recall | 31 | 4.93 | 8.21 | 0 – 29 | 17 (54%) |
| Letter Number Sequencing | 37 | 5.43 | 4.00 | 0 – 15 | 20 (54%) |

| | | | | | |
|--|----|-------|-------|---------|------------|
| BIT Start Cancellation | 38 | 45.44 | 9.80 | 17 – 54 | 18 (47%) |
| VOSP Incomplete Letters | 37 | 15.15 | 5.01 | 7 – 20 | 18 (49%) |
| VOSP Dot Counting | 39 | 7.86 | 2.91 | 0 – 10 | 18 (46%) |
| VOSP Position Discrimination | 26 | 17.36 | 3.51 | 7 – 20 | 9 (34%) |
| COWAT: FAS | 40 | 25.44 | 14.09 | 2 – 68 | 12 (30%) |
| Logical Memory II | 40 | 13.33 | 9.25 | 0 – 27 | 14 (35%) |
| Rey Delayed | 28 | 8.25 | 9.51 | 0 – 27 | 15 (54%) |
| MCST | 22 | 7.08 | 6.41 | 1 – 22 | 10 (45%) |
| Brixton Spatial Anticipation Test (Errors) | 27 | 24.68 | 9.34 | 2 – 31 | 18 (69%) |
| Overall conclusions | 40 | | | | 33 (82.5%) |

Further analysis indicated that the scores on the RBANS total scale were not related to type of stroke (i.e. TACS, PACS, POCS, or Lacunar): $F = 1.25$, $p > 0.3$, or hemisphere of stroke: $t = -0.10$, $p > 0.9$. Analysis also showed that there was no statistically significant correlation between RBANS Total Scale scores and days from admission: $r = 0.13$, $p > 0.4$, or the interval between testing on the RBANS and full battery: $r = -0.18$, $p > 0.2$. Cause of stroke (i.e. haemorrhage or ischemia) did demonstrate a statistically significant difference on the RBANS Total scale ($t = -2.6$, $p < 0.05$) though the small number of haemorrhage classifications ($n = 4$) would invalidate this analysis (95%CI = -46.4 to -5.8).

Type of stroke was not a statistically significant predictor of classification of impaired / non-impaired on the full battery testing (Chi-square = 6.88, $p > 0.05$), neither was hemisphere of stroke (Chi-square = 0.48, $p > 0.7$). Neither days from admission nor the interval between testing showed a statistically significant relationship with classification by the full battery testing (days from admission: $U = 93$, $p > 0.5$, and interval between testing: $U = 77.5$, $p > 0.5$).

3.4 Diagnostic Validity Using Recommended Cut-Off Scores

Table 7 shows the sensitivity, specificity, PPV and NPV (with 95% confidence intervals) for RBANS global and domain specific conclusions for impairment following stroke, based on the manual recommended cut-off of <69 (Randolph, 1998) when compared to the full battery conclusions, with adequate levels being highlighted. Using the recommended cut-off score, the RBANS Total Scale showed 100% specificity to global cognitive impairment (95% CI = 56-100) but poor sensitivity (52%, 95% CI = 34-69). Identification of impairment on 1 or more Indexes showed adequate levels of both sensitivity and specificity (82%, 95% CI = 63-92, and 100%, 95% CI = 56-100) for detecting global cognitive impairment after stroke.

None of the domain specific indexes demonstrated adequate sensitivity, though all demonstrated acceptable levels of specificity (Immediate Memory = 79%, 95%CI = 60-91, Visuospatial = 94%, 95% CI = 68-99, Attention = 79%, 95% CI = 54-93, and Delayed Memory = 81%, 95% CI = 57-94). PPV ranged from 57-100%, with Total Scale (100%, 95% CI = 77-100), Impairment Identified on 1 or more Indexes (100%, 95% CI = 84-100), and Visuospatial (95%, 95% CI = 73-100) showing good accuracy for positive results. Good accuracy for negative results was only shown by the Immediate Memory scale (NPV = 88%, 95%CI = 69-97).

Table 7. Sensitivity, specificity, positive and negative predictive values for RBANS conclusions based on recommended cut-off scores

| <i>RBANS Index (Subtest)</i> | <i>Sensitivity (95% CI)</i> | <i>Specificity (95% CI)</i> | <i>Positive Predictive Value (95% CI)</i> | <i>Negative Predictive Value (95% CI)</i> |
|---------------------------------------|---------------------------------|---------------------------------|---|---|
| Total Scale | 52% (34-69) | 100% (56–100) | 100% (77-100) | 30% (14-53) |
| Impairment on 1 or more Indexes | 82% (63-92) | 100% (56-100) | 100% (84-100) | 54% (26-80) |
| Immediate Memory | 73% (39-93) | 79% (60-91) | 57% (30-81) | 88% (69-97) |
| Visuospatial | 79% (57-92) | 94% (68-99) | 95% (73-100) | 75% (51-90) |
| Attention | 57% (33-77) | 79% (54-93) | 75% (47-91) | 63% (40-80) |
| Delayed Memory | 63% (39-83) | 81% (57-94) | 75% (47-92) | 71% (49-87) |

3.5 Cross Tabulations

Table 8 shows the cross tabulations for RBANS scores and full battery conclusions for Cognitive Impairment (CI) and Cognitive Non-Impairment (NCI) using RBANS recommended cut off point of 69 to identify CI. For the RBANS Total Scale and Index Conclusions (i.e. categorisation of CI on at least one of the indexes), the full battery conclusions are based on categorisation of CI/NCI in any single domain; for the RBANS domain specific conclusions, the full battery conclusions are based on categorisation of CI/NCI on the corresponding cognitive domain.

Table 8. RBANS Total and Index scales cut off score < 69 and Full Battery overall conclusions

| | Full Battery Conclusions | | | |
|--------------------------------|---------------------------------|-----|----|--------|
| | | NCI | CI | Totals |
| RBANS Total Scale | CI | 0 | 17 | 17 |
| | NCI | 7 | 16 | 23 |
| | Totals | 7 | 33 | 40 |
| RBANS Index Conclusions | CI | 0 | 27 | 27 |
| | NCI | 7 | 6 | 13 |
| | Totals | 7 | 33 | 40 |

| | | | | |
|---------------------------------|--------|----|----|----|
| Immediate Memory | CI | 6 | 8 | 14 |
| | NCI | 23 | 3 | 26 |
| | Totals | 29 | 11 | 40 |
| Visuospatial | CI | 1 | 19 | 20 |
| | NCI | 15 | 5 | 20 |
| | Totals | 16 | 24 | 40 |
| Attention | CI | 4 | 12 | 16 |
| | NCI | 15 | 9 | 24 |
| | Totals | 19 | 21 | 40 |
| <i>Delayed</i> Memory | CI | 4 | 12 | 16 |
| | NCI | 17 | 7 | 24 |
| | Totals | 21 | 19 | 40 |

Table 9 shows the cross tabulations for RBANS scores and full battery conclusions for Cognitive Impairment (CI) and Cognitive Non-Impairment (NCI) using RBANS optimum cut off points as identified by ROC analysis.

Table 9. RBANS Total Scale and Index scores (with ROC analysis identified optimum cut off scores) and Full Battery overall conclusions

| | Full Battery | Conclusions |
|--|---------------------|--------------------|
| | NCI | CI |

| | Totals | | | |
|--|--------|----|----|----|
| RBANS Total Scale (102.5) | CI | 2 | 33 | 35 |
| | NCI | 5 | 0 | 5 |
| | Totals | 7 | 33 | 40 |
| Immediate Memory (79.5) | CI | 8 | 9 | 17 |
| | NCI | 21 | 2 | 23 |
| | Totals | 29 | 11 | 40 |
| Visuospatial (88) | CI | 4 | 24 | 28 |
| | NCI | 12 | 0 | 12 |
| | Totals | 16 | 24 | 40 |
| Attention (86.5) | CI | 10 | 18 | 28 |
| | NCI | 9 | 3 | 12 |
| | Totals | 19 | 21 | 40 |
| <i>Delayed</i> Memory (90.5) | CI | 8 | 18 | 26 |
| | NCI | 13 | 1 | 14 |
| | Totals | 21 | 19 | 40 |

Tables 10 shows the cross tabulations for RBANS total and index scores and full battery conclusions for Cognitive Impairment (CI) and Cognitive Non-

Impairment (NCI) on Executive Function tests, using RBANS recommended cut off points of 69. (N.B. that the Language scale was artificially affected by language impairment being a study exclusion criterion).

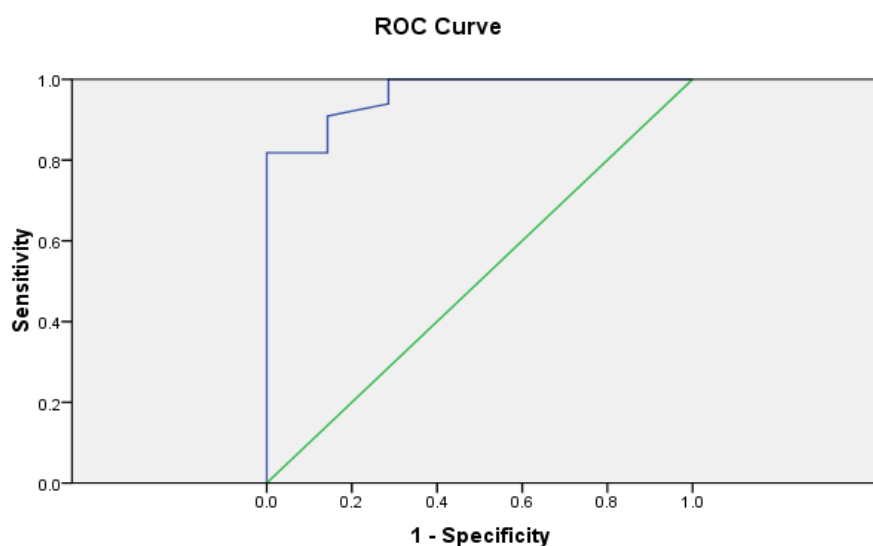
Table 10. RBANS Total scale and index scores and full battery conclusions for executive functioning impairment

| | Full Battery Conclusions | | | |
|--------------------------|---------------------------------|-----|----|--------|
| | | NCI | CI | Totals |
| RBANS Total Scale | CI | 1 | 16 | 17 |
| | NCI | 15 | 8 | 23 |
| | Totals | 16 | 24 | 40 |
| Immediate Memory | CI | 1 | 13 | 14 |
| | NCI | 15 | 11 | 26 |
| | Totals | 16 | 24 | 40 |
| <i>Language</i> | CI | 0 | 6 | 6 |
| | NCI | 16 | 18 | 34 |
| | Totals | 16 | 24 | 40 |
| Visuospatial | CI | 4 | 16 | 20 |
| | NCI | 12 | 8 | 20 |

| | | | | |
|---------------------------------|--------|----|----|----|
| | Totals | 16 | 24 | 40 |
| Attention | CI | 3 | 13 | 16 |
| | NCI | 13 | 11 | 24 |
| | Totals | 16 | 24 | 40 |
| <i>Delayed</i> Memory | CI | 0 | 16 | 16 |
| | NCI | 16 | 8 | 24 |
| | Totals | 16 | 24 | 40 |

3.6 Receiver Operating Characteristic and Area Under the Curve Conclusions

Figure 2. ROC curve analysis for full battery neuropsychological testing and RBANS Total scale



Diagonal segments are produced by ties.

Table 11. AUC analysis for full battery neuropsychological testing and RBANS Total scale

Area Under the Curve

Test Result Variable: RBANS Total Index Score

| Area | Std. Error | Asymptotic Sig | 95% Confidence Interval | |
|------|------------|-------------------|-------------------------|----------------|
| | | | Lower Bound | Upper Bound |
| | | | | |

| | | | | |
|------|------|------|------|-------|
| .963 | .030 | .000 | .000 | 1.000 |
|------|------|------|------|-------|

Table 12. Optimum cut off scores for RBANS Total scale.

Coordinates of the Curve

Test Result Variable(s):RBANS

Total Index Score

| Positive if Less Than or Equal To | Sensitivity | Specificity |
|---|-------------|-------------|
| 43.00 | .000 | 1.000 |
| 45.50 | .030 | 1.000 |
| 47.50 | .061 | 1.000 |
| 48.50 | .091 | 1.000 |
| 50.00 | .121 | 1.000 |
| 51.50 | .152 | 1.000 |
| 52.50 | .212 | 1.000 |
| 54.50 | .242 | 1.000 |
| 59.00 | .273 | 1.000 |
| 63.00 | .303 | 1.000 |
| 64.50 | .333 | 1.000 |

| | | |
|--------|-------|-------|
| 65.50 | .364 | 1.000 |
| 66.50 | .424 | 1.000 |
| 67.50 | .455 | 1.000 |
| 68.50 | .515 | 1.000 |
| 70.00 | .545 | 1.000 |
| 72.50 | .606 | 1.000 |
| 74.50 | .636 | 1.000 |
| 76.00 | .667 | 1.000 |
| 79.00 | .727 | 1.000 |
| 82.00 | .758 | 1.000 |
| 83.50 | .818 | 1.000 |
| 85.00 | .818 | .857 |
| 86.50 | .848 | .857 |
| 88.50 | .909 | .857 |
| 93.50 | .939 | .714 |
| 97.50 | .970 | .714 |
| 102.50 | 1.000 | .714 |
| 107.50 | 1.000 | .508 |
| 112.50 | 1.000 | .429 |
| 117.50 | 1.000 | .286 |
| 119.50 | 1.000 | .143 |
| 122.00 | 1.000 | .000 |

Acceptable levels of sensitivity and specificity are highlighted.

Figure 3. ROC curve analysis for full battery neuropsychological testing of immediate memory RBANS Immediate Memory Index.

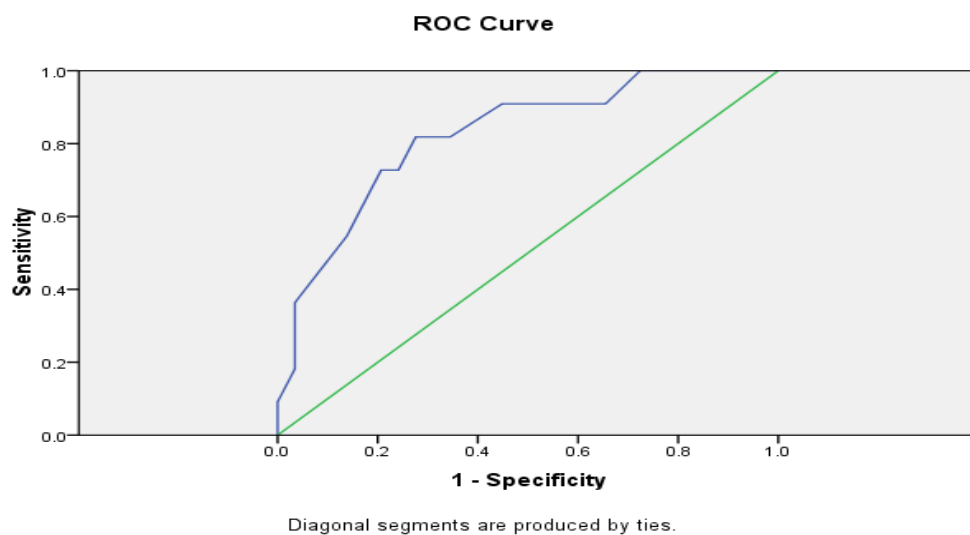


Table 13. AUC analysis for full battery neuropsychological testing of immediate memory and RBANS Immediate Memory Index

Area Under the Curve

Test Result Variable: RBANS Immediate Memory Index

Score

| Area | Std. Error | Asymptotic Sig. | 95% Confidence Interval | |
|------|------------|--------------------|-------------------------|----------------|
| | | | Lower Bound | Upper Bound |
| | | | | |

| | | | | |
|------|------|------|------|------|
| .823 | .073 | .002 | .679 | .966 |
|------|------|------|------|------|

Table 14. Optimum cut off scores for RBANS Immediate Memory Index.

Coordinates of the Curve

Test Result Variable(s):RBANS

Immediate Memory Index Score

| Positive if Less Than or Equal To | Sensitivity | Specificity |
|---|-------------|-------------|
| 39.00 | .000 | 1.000 |
| 44.50 | .091 | 1.000 |
| 51.00 | .182 | .966 |
| 55.00 | .364 | .966 |
| 59.00 | .545 | .862 |
| 68.50 | .727 | .739 |
| 77.00 | .727 | .759 |
| 79.50 | .818 | .724 |
| 82.00 | .818 | .655 |
| 85.00 | .909 | .552 |

| | | |
|--------|-------|------|
| 88.50 | .909 | .517 |
| 93.50 | .909 | .448 |
| 98.50 | .909 | .414 |
| 101.50 | .909 | .345 |
| 104.50 | 1.000 | .276 |
| 107.50 | 1.000 | .207 |
| 111.00 | 1.000 | .138 |
| 115.00 | 1.000 | .103 |
| 118.50 | 1.000 | .069 |
| 121.50 | 1.000 | .034 |
| 124.00 | 1.000 | .000 |

Acceptable levels of sensitivity and specificity are highlighted

Figure 4. ROC curve analysis for full battery neuropsychological testing of visuospatial impairment and the RBANS Visospatial/Constructional Index.

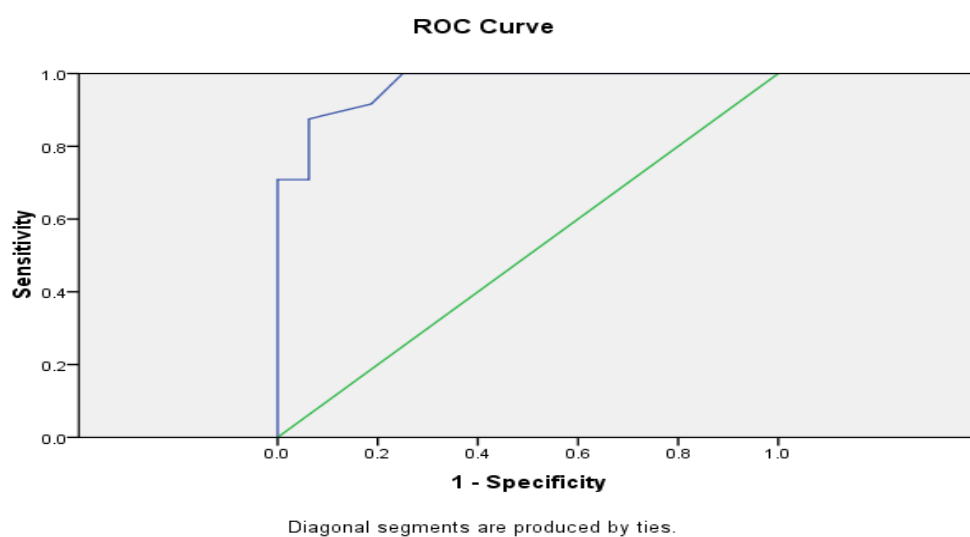


Table 15. AUC analysis for full battery neuropsychological testing of visuospatial impairment and RBANS Visuospatial/Constructional Index

Area Under the Curve

Test Result Variable:RBANS Visuo/spacial Index Score

| Area | Std. Error | Asymptotic Sig. | 95% Confidence Interval | |
|------|------------|--------------------|-------------------------|----------------|
| | | | Lower Bound | Upper Bound |
| .966 | .024 | .000 | .000 | 1.000 |

Table 16. Optimum cut off scores for RBANS Visuospatial/Constructional Index.

Coordinates of the Curve

Test Result Variable(s):RBANS

Visuo/spacial Index Score

| Positive if Less Than or Equal To | Sensitivity | Specificity |
|---|-------------|-------------|
| 39.00 | .000 | 1.000 |

| | | |
|--------|-------|-------|
| 45.00 | .042 | 1.000 |
| 53.00 | .333 | 1.000 |
| 57.00 | .375 | 1.000 |
| 59.00 | .542 | 1.000 |
| 61.00 | .583 | 1.000 |
| 63.00 | .667 | 1.000 |
| 65.00 | .708 | 1.000 |
| 67.50 | .708 | .937 |
| 72.00 | .792 | .937 |
| 78.00 | .875 | .937 |
| 82.50 | .917 | .812 |
| 88.00 | 1.000 | .750 |
| 94.00 | 1.000 | .687 |
| 102.50 | 1.000 | .500 |
| 110.50 | 1.000 | .437 |
| 114.00 | 1.000 | .312 |
| 118.50 | 1.000 | .187 |
| 126.00 | 1.000 | .062 |
| 132.00 | 1.000 | .000 |

Acceptable levels of sensitivity and specificity are highlighted.

Figure 5. ROC curve analysis for full battery neuropsychological testing of attention and the RBANS Attention Index.

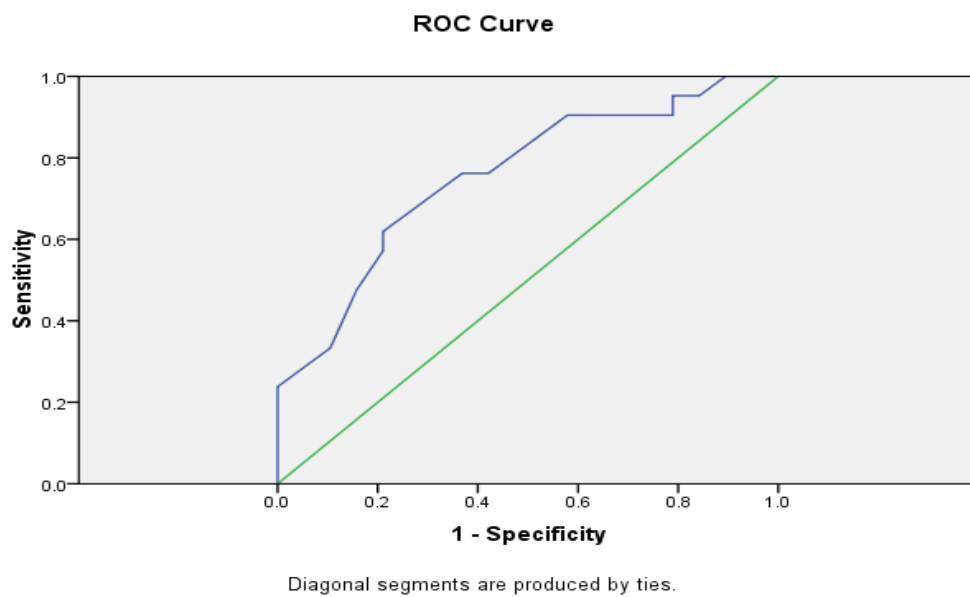


Table 17. AUC analysis for full battery neuropsychological testing of attention and RBANS Attention Index.

Area Under the Curve

Test Result Variable: RBANS Attention Index Score

| Area | Std. Error | Asymptotic Sig. | 95% Confidence Interval | |
|------|------------|--------------------|-------------------------|----------------|
| | | | Lower Bound | Upper Bound |
| .757 | .076 | .006 | .607 | .907 |

Table 18. Optimum cut off scores for RBANS Attention Index.

Coordinates of the Curve

Test Result Variable: RBANS

Attention Index Score

| Positive if Less Than or Equal To | Sensitivity | Specificity |
|---|-------------|-------------|
| 45.00 | .000 | 1.000 |
| 47.50 | .048 | 1.000 |
| 51.00 | .143 | 1.000 |
| 54.50 | .190 | 1.000 |
| 58.00 | .238 | 1.000 |
| 62.00 | .333 | .895 |
| 66.00 | .476 | .842 |
| 70.00 | .571 | .789 |
| 73.50 | .619 | .789 |
| 77.00 | .667 | .737 |
| 80.50 | .762 | .632 |

| | | |
|--------|-------|------|
| 83.50 | .762 | .579 |
| 86.50 | .857 | .474 |
| 89.50 | .905 | .421 |
| 92.50 | .905 | .368 |
| 95.50 | .905 | .316 |
| 98.50 | .905 | .211 |
| 101.00 | .952 | .211 |
| 102.50 | .952 | .158 |
| 104.50 | 1.000 | .105 |
| 117.00 | 1.000 | .053 |
| 129.00 | 1.000 | .000 |

Acceptable levels of sensitivity and specificity are highlighted.

Figure 6. ROC curve analysis for full battery neuropsychological testing of delayed memory and the RBANS Delayed Memory Index.

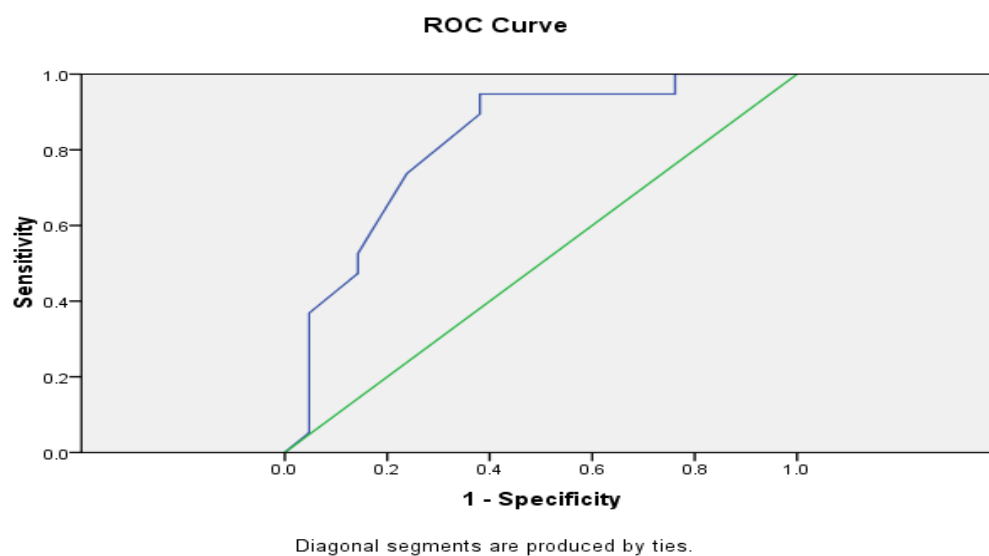


Table 19. AUC analysis for full battery neuropsychological testing of delayed memory and RBANS Delayed Memory Index.

Area Under the Curve

Test Result Variable: RBANS Delayed Memory Index Score

| Area | Std. Error | Asymptotic Sig. | 95% Confidence Interval | |
|------|------------|--------------------|-------------------------|----------------|
| | | | Lower Bound | Upper Bound |
| .817 | .069 | .001 | .682 | .952 |

Table 20. Optimum cut off scores for RBANS Delayed Memory Index.

Coordinates of the Curve

Test Result Variable: RBANS

Delayed Memory Index Score

| Positive if Less Than or Equal To | Sensitivity | Specificity |
|---|-------------|-------------|
| 39.00 | .000 | 1.000 |
| 42.00 | .053 | .952 |

| | | |
|--------|-------|------|
| 46.00 | .105 | .952 |
| 50.00 | .263 | .952 |
| 54.00 | .316 | .952 |
| 58.00 | .368 | .952 |
| 62.00 | .474 | .857 |
| 66.00 | .526 | .857 |
| 69.50 | .632 | .810 |
| 73.00 | .737 | .762 |
| 76.50 | .789 | .714 |
| 82.00 | .895 | .619 |
| 90.50 | .947 | .619 |
| 96.50 | .947 | .476 |
| 100.00 | .947 | .333 |
| 102.50 | .947 | .238 |
| 106.50 | 1.000 | .238 |
| 111.00 | 1.000 | .190 |
| 113.50 | 1.000 | .095 |
| 117.00 | 1.000 | .048 |
| 120.00 | 1.000 | .000 |

Acceptable levels of sensitivity and specificity are highlighted.

3.7 Sample size calculation

Based on the full battery overall conclusions for the prevalence rate of cognitive impairment following stroke, the sample size calculation would be:

$$W = \pm 0.10$$

$$P = 0.80$$

$$SN = 0.80$$

$$SP = 0.90$$

Calculate the Number with Disease, TP + FN:

$$TP + FN = 1.96 \times 1.96 \frac{0.8(1-0.8)}{0.1 \times 0.1}$$

$$= 3.842 \times \frac{0.16}{0.01}$$

$$= 61.472$$

Calculate the Sample Size Required for Sensitivity, N1:

$$N1 = \frac{TP+FN}{P}$$

$$= \frac{61.472}{0.8}$$

$$= 76$$

Calculate the Number without Disease, FP +TN:

$$\begin{aligned} FP + TN &= 1.96 \times 1.96 \frac{0.9(1-0.9)}{0.1 \times 0.1} \\ &= 3.842 \times \frac{0.09}{0.01} \\ &= 34.578 \end{aligned}$$

Calculate the Sample Size Required for Specificity, N2:

$$\begin{aligned} N2 &= \frac{FP+TN}{(1 - P)} \\ &= \frac{34.578}{0.3} \\ &= 116 \end{aligned}$$

As $N2 > N1$, the statistically calculated sample size for overall cognitive impairment was 116 participants.

Based on the domain specific index with the lowest prevalence rate (Immediate Memory) the sample size calculation would be:

$$\begin{aligned} W &= +/-0.10 \\ P &= 0.30 \\ SN &= 0.80 \\ SP &= 0.70 \end{aligned}$$

Calculate the Number with Disease, TP + FN:

$$TP + FN = 1.96 \times 1.96 \frac{0.8(1-0.8)}{0.1 \times 0.1}$$

$$0.1 \times 0.1$$

$$= 3.842 \times \frac{0.16}{0.01}$$

$$= 61.472$$

Calculate the Sample Size Required for Sensitivity, N1:

$$N1 = \frac{TP+FN}{P}$$

$$= \frac{61.472}{0.3}$$

$$= 205$$

Calculate the Number without Disease, FP +TN:

$$FP + TN = 1.96 \times 1.96 \frac{0.7(1-0.7)}{0.1 \times 0.1}$$

$$= 3.842 \times \frac{0.21}{0.01}$$

$$= 80.682$$

Calculate the Sample Size Required for Specificity, N2:

$$N2 = \frac{FP+TN}{(1 - P)}$$

$$= \frac{80.682}{0.7}$$

= 115

As $N_1 > N_2$, the statistically calculated sample size for Immediate Memory was 205 participants.

4. EXTENDED DISCUSSION

4.1 Further interpretation of results

Analysis of the demographic variables indicated that age, gender and years of education were not normally distributed. With regard to age, this would be a reflection of the incidence of stroke increasing with age (Hankey, 2002) and would therefore follow the expected trend. Gender is reported to be unrelated to stroke incidence (Hankey, 2002) and therefore suggests that the sample in this study was biased towards male participants ($N=25$, 62% of sample). This may have been due to intrinsic gender differences in participation in research studies, though there is nothing in the literature to suggest that this might be the case (e.g. Harris & Dyson, 2001). A more likely explanation is that the three acute stroke wards from which participants were drawn from for this study are split between one mixed and two non-mixed wards, and that relationships between the ward staff and the researchers, or differences in ward practices, biased recruitment in favour of the male ward. This had an impact on the study results in that no female participants were identified as unimpaired, and therefore it could limit the generalisation of this study's conclusions to the general population. However, in terms of calculating rates of sensitivity and specificity, this would not be a factor, as this is based on the characteristics of the test itself rather than the make up of the sample.

The non-normal distribution of years of education may have been due to a cohort effect reflected in the bias within the sample towards people aged over 65 as opposed to relatively fewer people recruited at an age when years of compulsory education was increased (Stuart-Hamilton, 2000). There was a statistically significant relationship between years of education and scores on both the RBANS and full battery. With regards to the RBANS, only age is controlled for within the normative data, and it has been argued that education

has a significant effect on neuropsychological test scores (e.g. Stuart-Hamilton, 2000). Whilst years of education was estimated from the S-NART for the full battery, this was only used to control for norming on some of the tests (e.g. the COWAT). In clinical practice, years of education (as well as many other factors) would contribute to drawing conclusions from neuropsychological test results (Darby & Walsh, 2005), and this is an important consideration when considering the use of a screening test for post stroke cognitive impairment, in that the test score, regardless of its sensitivity and specificity, only has meaning when considered in light of a wider biopsychosocial understanding of a persons presentation.

With regards to the potential effect of the relatively rapid spontaneous remission of cognitive impairments often seen following stroke (Johnstone & Stonnington, 2001) having an impact on the results of this study, analysis of the data would suggest that this was well controlled for. Neither the RBANS or full battery test scores related to days from admission ($r=0.13$, $p>0.4$ and $U=93$, $p>0.5$ respectively) or interval between testing ($r=-0.18$, $p>0.2$ and $U=777.5$, $p>0.5$ respectively) suggesting that the days between testing (mean = 3.6 days, $SD=4.6$) was close enough to control against spontaneous remission effects, and this combined with the added control of alternating the administration of tests, suggests that the results presented in this study are measuring comparable clinical presentations.

The results of this study suggested that the cut off score of 69 recommended by the RBANS manual as a classification of 'Extremely Low' (Randolph, 1998) appeared to be too low for accurate discrimination of impairment / non-impairment for this sample as measured by the full battery testing with the exception of Immediate Memory. This may have been because the sample in this study was an unusual or atypical representation of the population. A possible explanation for this may have been that the patients who consented to participate were different to those who declined to participate, though because no data was recorded for the non-participants this is unknown. However, previous research would suggest that in comparable studies this has tended not to be the case in that there is little statistically significant difference between

those who consent and those who decline to participate (e.g. Nys *et al*, 2005). It could also have been because the full battery testing was not appropriate to discriminate impairment from non-impairment. This could be possible as the full battery was not extensive enough to measure all possible impairments due to the excessively high testing load that this would have placed on participants. A further explanation could be that the sample represented in this study was not from a community that was comparable to the normative sample for the RBANS. However, whilst possible, this too would seem an unlikely explanation as the hospital at which the study was conducted covered an extensive geographical area made up of diverse rural and urban communities. A more likely explanation is that the cut off scores identified by the manual provide only a guide to the general population and that this score is not applicable to a sample made up from stroke patients with (usually) focal impairments. Duff *et al* (2008) made similar conclusions when reporting optimum cut off scores for cognitive impairment in people with dementia.

When using ROC identified optimum cut off scores, the cross tabulations suggested that the RBANS misdiagnosed 13 out of 40 (33%) participants on conclusions for Attention, as well as misdiagnosing 9 out of 40 (22%) participants on conclusions for Immediate and 11 out of 40 (27.5%) for Delayed Memory. The latter was slightly surprising given that the RBANS was developed as a screening test for dementia, where memory impairments are often highlighted. Again, whilst possible that this was due to a lack of diagnostic validity on the RBANS there are other potential reasons. Firstly, it is possible that given the small sample size, and especially the relatively small number of participants categorised as no cognitive impairment, these results were mere anomalies. It could also have been the case that the full battery tests lacked diagnostic validity, though this would appear to be unlikely as it would imply that the RBANS has better diagnostic validity than the full battery, and this is not reflected in the general body of literature in terms of the reliability and validity of all the tests outlined in the introduction. None the less, the Immediate Memory conclusions still represented adequate sensitivity (82%) and specificity (72%) at a cut off score of 79.5, and the Attention index demonstrated adequate sensitivity at 86%% at a cut off score of 86.5, though specificity was poor at

47%, probably related to the use of a motor task as discussed in the Journal Paper 'Discussion'.

It was also worth noting that the recommended cut off score for the RBANS Total scale was not particularly sensitive to overall conclusions for cognitive impairment, misdiagnosing 16 out of 33 (48%) categorised as impaired by the full battery tests, though it did not misdiagnose any participants as non-cognitively impaired suggesting that the cut-off of 69 was too low (as opposed to measuring different constructs) even when compared to a cut-off of 5% on the full battery. However, the figure reduced to 6 out of 33 (18%) misdiagnosed when impairment was identified on any one of the index scores. This would indicate that the RBANS Total scale was not particularly sensitive to impairment the test itself identifies, when using a cut off of <69, potentially due to differences in labelling of cognitive domains (including, potentially, executive functioning) as discussed in the Journal Paper 'Discussion'

The results suggested that the RBANS was sensitive to executive functioning impairment, as suggested by Wilde (2006). This was especially true of the Total Scale and Delayed Memory index of the RBANS. Ryusaku *et al* (2004) have argued that the underlying mechanism for memory loss in people with mild dementia (as measured by list learning tasks) is an impairment of executive functioning, and this may be what the Delayed Memory scale is sensitive to. The Total Scale may be measuring differing aspects of executive functioning as a more global construct, as discussed in the Journal Paper 'Discussion'.

Bearing in mind that there are limitations to this study resulting from the relatively small sample size, there remains the possibility that the RBANS could be a useful aid for clinical psychologists working with stroke patients. The results of this study were that the RBANS correctly identified 8 out of 10 participants as being non-impaired on global cognitive conclusions. Given that the hospital where this study was completed admits approximately 800 stroke patients per year, this would mean that the RBANS would correctly identify 337 patients as not requiring detailed investigation of potential cognitive impairment. This would still leave 299 stroke patients correctly identified as having a

cognitive impairment in at least 1 domain, and whilst this is a large number of people to complete in depth neuropsychological testing with, it is still substantially smaller figure than the 560 people predicted by the prevalence rate reported by Nys *et al* (2005). A further advantage of the RBANS is that its apparent sensitivity and specificity to specific cognitive impairment means that the neuropsychological testing may be appropriately guided towards focused investigations and consequently it could help to make best use of the clinical psychologists' time and resources as well as identifying more rapidly those stroke patients who would benefit from more detailed neuropsychological investigation.

4.2 Implications for Clinical Psychologists working in stroke services

The results presented here would suggest that the RBANS might be a valid test of diagnostic accuracy in screening for post stroke cognitive impairment. Diagnostic categories can be useful to clinical psychologists for three main reasons. Firstly, it can help to justify further interventions, as in stroke services where a score on a screening test would indicate the need for monitoring the cognitive status of the client, or the need for more detailed assessment. Clinical psychologists can also use this information to gather base rate data and to help inform the effectiveness of interventions. Secondly, some people (including both survivors of stroke and their families) can find having a diagnosis useful in understanding and coming to terms with difficulties experienced post stroke. Thirdly, and especially pertinent in an in-patient medical setting, diagnostic categories can aid communication with other professional colleagues, being used as a type of medical 'short-hand' (though difficulties in communication can occur when the interpretation of this short-hand differs between professional groups). Consequently, a test that demonstrates high levels of diagnostic accuracy can inform a part of both the direct and indirect work undertaken by clinical psychologists when working with survivors of stroke.

Given the high prevalence rate of cognitive impairment following stroke, the RBANS high levels of specificity to global cognitive impairment can be useful to clinical psychologists in identifying people who do not require further assessment of cognitive impairment, as discussed above, and can therefore be of use in managing limited time and resources. However, a screening test of post stroke cognitive impairment could also be a useful resource for clinical psychologists working in stroke services in providing information on the type and severity of any identified impairment. Despite the RBANS being somewhat lengthier to administer compared to other comparable screening tests (such as the MMSE and ACE-R), it does have an advantage over these tests in that it can provide information that is clinically useful to a clinical psychologist.

Whilst diagnoses can be useful to clinical psychologists (as discussed above), in clinical practice they are more concerned with working with the individual and his or her idiosyncratic presentation. The impact of a stroke can be devastating, both for the individual and their families. However, the way a person reacts to this will depend not only on the nature, extent and severity of the stroke but also on many other factors including previous experiences, current thoughts, beliefs and interpretations, and their environment, including the provision of support (Darby & Walsh, 2005). Consequently, a screening test of post stroke cognitive impairment that has good levels of sensitivity to domain specific cognitive impairment is more useful to a clinical psychologist than a general measure of overall cognitive impairment. This information can then be useful (within the wider formulation) to hypothesise potential difficulties that the individual may face following stroke (provided that the test has adequate ecological validity, which has been reported as good for the RBANS with a stroke population by Larson *et al*, 2003) and to tailor specific, person centred interventions, usually focussed on compensation approaches which have been shown to help a person emotionally adjust to the consequences of stroke (Lincoln, 2005).

Given that the results presented here suggest that the RBANS may have adequate sensitivity to the cognitive domains measured by its index scales (with the exception of attention as discussed above, and noting the lack of a specific index for executive functioning) the test would therefore be a useful additional resource for clinical psychologists working in stroke services. However, clinical psychologists are trained to make interpretations from such data (BPS, 2010), and the routine screening of survivors of stroke needs to be approached with some caution, as interpretation by clinicians unskilled in relating such test results to a person's individual presentation could result in incorrect conclusions. For instance, the data presented here would indicate that how many years of education a person has had will have an effect on the conclusions that can be drawn from the RBANS test results, or that a low score on the Attention index may be a result of motor difficulties rather than cognitive impairment. National guidelines suggest that clinical psychologists should be employed by stroke services to provide such expert interpretation (Department of Health, 2007),

though in the current financial climate cuts are a likely threat to the provision of this. However, cognitive impairment and its consequences following stroke would still remain a significant issue for a large number of people (Walford, Soljak & Majeed, 2009) and research into the screening of post stroke cognitive impairment would be justified in light of how this can be useful for clinical psychologists, stroke services generally (and by implication, for people who have had a stroke), and in continuing further research into the RBANS specifically given its potential clinical utility when compared to other similar screening tests.

4.3 Feasibility of Extended Study

This pilot study was completed to establish the potential justification for and feasibility of conducting a full scale study into the diagnostic validity of the RBANS as a sensitive and specific screening test of post stroke cognitive impairment. As such, the results are presented as a tentative conclusion with a view to justifying (or otherwise) further research. Based on the results of this pilot (including the lack of specificity of the Attention index, which may be due to comparative difficulties with the full battery testing as outlined above) and taking into account the need for research into screening tests for post stroke cognitive impairment (as outlined in the introduction and also discussed in 'Implications for Clinical Psychologists working in stroke') it would appear that an extended study into the sensitivity and specificity of the RBANS as a screening test for post stroke cognitive impairment is justified.

The feasibility of an extended study is concerned with two general areas, the resource commitments and the impact of testing on participants, and there is significant overlap between the two. These considerations can be broken down further into:

- Prevalence rates and sample size
- Recruitment and consent
- Adherence to 'between testing' timelines
- Researcher commitments
- Costs
- Full Battery testing

Prevalence rate and sample size

Burderer (1996) argued that in order to be meaningful, the sample should reflect the prevalence rate of a particular disorder. As reported, the prevalence rate identified within this study is comparable with that of other studies. However, two

of these other studies (Cartoni & Lincoln, 2005, and Nys *et al*, 2005) had similar sample sizes to that reported in this study. Equally, there was a wide range of reported prevalence rates when taking into account all comparable studies (including Blake *et al*, 2002), a problem that is compounded when considering impairment in specific cognitive domains, where the sample of participants with a particular cognitive impairment is smaller than the overall impairment prevalence. This discrepancy could be due to several factors including those outlined in the introduction, such as differences in exclusion criteria or the use of differing 'gold standard' tests. It is thus difficult to estimate a sample size based on Burdener's (1996) calculations without a greater consensus about prevalence rates.

A complicating factor regarding the prevalence rate of cognitive impairment following stroke is that two of the published studies of evaluation of sensitivity and specificity have included evaluation of the MMSE (i.e. Blake *et al*, 2002, and Nys, 2005,). This study did not gather enough information regarding the MMSE to make reporting it useful. This was unfortunate as the conclusions of the MMSE, whilst not sensitive or specific to post stroke cognitive impairment, could provide a base rate from which comparisons with other studies might be drawn, especially given its ubiquitous use in clinical practice. It is interesting to note that Nys *et al* (2005) and Blake *et al* (2002) reported a prevalence rate of cognitive impairment following stroke of 35% and 31% respectively, with a cut off score of <24 though drew different conclusions. A further complicating factor in the estimation of prevalence rates for domain specific cognitive impairment is the heterogeneous nature of impairment following stroke.

With these factors taken into account, the power calculations to give an adequate sample size presented in the results suggested that if an extended study was to focus exclusively on the RBANS as a sensitive and specific test of global post stroke cognitive impairment, then the sample would be 116 participants. If an extended study were to examine the RBANS as a sensitive and specific test of domain specific cognitive impairment, then the sample size would be 205. In light of the discussions above, it would be recommended that the RBANS has greater clinical utility when used to screen for domain specific

cognitive impairment, and the recommendation would therefore be to recruit a sample of 205

Recruitment and consent

This pilot study had a consent rate of 47 out of 146 (32%) of people who met the inclusion / exclusion criteria, with a drop out rate of 7 out of 47 (14%). The drop out rate was comparable to other studies where this has been reported (e.g. Cartoni & Lincoln, 2005). It would appear that the consent rate was not affected by the time commitments or effort that participation entailed, and therefore other issues should be considered that might improve the consent rate. One of these would be to relax the exclusion criteria, and it would be recommended that the cut-off age of 80 be raised and the tests pro-rated to increase the pool size of potential participants.

Adherence to 'between testing' timelines

Ethical approval was given for the study to allow up to two weeks between RBANS and full battery test. However, the execution of this study placed a strong emphasis on completing the testing within as short a time period as possible. There are advantages and disadvantages to this approach. Keeping the timeline short meant that spontaneous remission was not a factor in the study results, and greater confidence could be placed in the assertion that the results reflected measurement of the same clinical presentation. However, a short timeline increases the potential risk of a practice effect influencing the results, and it also places a greater testing strain on participants. The latter however was not reported as being problematical by any of the participants in this study, and it would be recommended that the procedure employed by this study in relation to time between testing be retained.

Researcher commitments

The pilot study was conducted over a recruitment period of 26 weeks, though this did include holiday and study leave. Leave had an additional complication in

that when one of the two researchers was away, research had to stop as neither the Chief Investigator or the Research Assistant could complete both tests, as each had to be blind to the alternate test results. Given that 40 participants completed all tests, this equated to an average recruitment of 1.5 participants per week. With a suggested sample size of 205, this would equate to the study taking 137 weeks (2.6 years). The researchers each attended the stroke wards two days per week to complete testing. Testing was confined to short periods of the day due to several factors including participants attending groups or being seen by hospital staff, protected meal times, and visiting times. The Chief Investigator attended at weekends, which made administration of the full batteries easier as the wards were far less busy (the Chief Investigator also attended for a half day during the week to liaise with ward staff and engage in participant recruitment).

To conduct an extended study that recruited the suggested 205 participants would therefore require a major commitment from the research team. To some extent this could potentially be mitigated by the publishing of this pilot study. Given that previous research has been comparable to this pilot in terms of sample size and confidence intervals, it would appear appropriate to consider the current (albeit limited) research evidence as suggesting that the RBANS is a more clinically valid test of post stroke cognitive impairment than those currently being used for routine screening (for instance the MMSE). If the RBANS was administered as part of the routine intake assessment, then consent and recruitment would only be required to complete the full battery tests. This would halve the time commitment of the researchers, though it would have an effect on other variables such as managing the between testing time. The hospital at which this study was completed now uses the RBANS as an adjunct to other screening tests in that if no impairment is identified by the MMSE or MoCA, then the RBANS is administered to provide more detailed information. However, using the RBANS as a routine assessment tool would have financial implications for the host trust, and this would also be inappropriate if clinical psychologists were not routinely available to interpret the test results as discussed above.

Costs

The cost of tests to complete this pilot study was £500, which came from a student research budget. This would make the cost of completing an extended study with 205 participants approximately £2700. The current study imposed no cost on the host trust as the Chief Researcher was employed by the NHS as a student, and the Research Assistants offered their time voluntarily. If similar arrangements could be found to complete an extended study then this would obviously keep costs down. Alternatively, funding could be applied for from other sources with the pilot being used as justification for extended research.

Full Battery testing

A final consideration of the feasibility of conducting an extended study was the research utility and participant toleration of the full battery testing. These points have been considered elsewhere in the discussion, and to summarise, the full battery was well tolerated by the participants of this pilot (with none citing it as a reason for withdrawal) and it would be recommended that the full battery include a test of Attention that incorporated motor skills to make comparison with the RBANS more equitable (though it should be noted that the conclusions of the full battery would still maintain interpretation based on a test being void if it were influenced by non-cognitive factors, though the inclusion of an attention/motor task would allow incorporation of this variable to be included in the results). It would also be suggest that the Rey Figure be replaced with a non motor test of visual memory as discussed previously.

Feasibility Summary

An extended study into the sensitivity and specificity of the RBANS as a screening test of post stroke cognitive impairment is justified for the reasons outlined above. The feasibility of such as study would be dependent on the

provision of resources in terms of research staff and financing, and would require a relatively substantial commitment. Suggestions have been made above to make changes to the study design that could have some effect in reducing the commitment needed without compromising the quality of the research, and it is suggested that given the need for a sensitive and specific screening test of post stroke cognitive impairment, and the potential evidenced in this pilot study for the RBANS to be suitable in this role, an extended study would be recommended.

4.4 Critical reflection

The design of this study was carefully considered (with credit for that going mainly to the research supervisor) and discussed with supervisors and others before being undertaken, and appeared to be appropriate for the research question being asked. The basic design was also similar to other studies asking the same research questions of differing screening tests (i.e. Blake *et al*, 2002, Cartoni & Lincoln, 2005, and Nys *et al*, 2005). As such, the conclusions of this study can be confidently interpreted as being related to the research question, and the results can be readily compared to other research (though this does not imply that the results can be confidently interpreted without reference to the limitations of the study, such as the relatively small sample size and large confidence intervals). Nonetheless, despite such a seemingly well-designed study, the practical execution of the research highlighted several complications that were unanticipated by the author and that led to various learning points.

The first of these concerned the timeline of the study, in that ethical approval took far longer to be granted by the local REC than expected. This was due to the author relying too heavily on previously published research to guide the ethics application, and not being mindful of basic premises of the research process, especially with regards to completing a formal power calculation to estimate the required sample size.

The reason for having a representative sample is to allow for greater generalisability of the results to inform clinical practice. There is thus an ethical dimension to having an adequate sample size, in that the people who consented to participate should have done so for a useful purpose. As Burdener (1996) makes clear, too small a sample size may result in imprecise estimates of sensitivity and specificity, and if the sample does not reflect the disorder prevalence rate of the population for which the test is designed to screen, then the information resulting from the study may be misleading. This was rectified by completing the study as a pilot in order to establish the justification for and

feasibility of conducting an extended study into the sensitivity and specificity of the RBANS as a screening test of post stroke cognitive impairment. This would allow evaluation of participant consent rates, the likelihood of anticipated time scales being adhered to (in terms of duration between testing), the tolerability of the testing load on participants, and the identification of unforeseen resource requirements. The learning point here was that in preparing for this study the author placed too great an emphasis on consulting previously published literature, and that research practices that have become established over time can become regarded as constituting clinically applicable or acceptable research, and that stepping outside of this practice can be difficult and anxiety provoking. However, the consequences of not doing so can not only lead to delays in the research being completed (a relatively minor consequence) but it can also lead to ethically questionable research being published and used to influence clinical practice. Whilst this did not have had any particular impact of the overall design of this study it did mean that the research was delayed, and that in the future the author would seek ethical approval at an earlier point in the process.

A further learning point related to working with the ward staff. Whilst weekly meetings were held between the chief investigator and members of the ward staff, to aid in identifying potential participants, these tended to be relatively informal and on an ad hoc basis. A consequence of this was that a large proportion of participants were identified away from these meetings, usually in discussion with the ward sisters or by speaking to one of the Occupational Therapists. Whilst this research would not have been a high priority for the ward staff, and therefore allocating time to formal research meetings would be inappropriate, given the number of different studies taking place it may have been appropriate to have had a more organised approach to liaising between the various researchers and the ward staff. This could have been organised to take place during a staff handover followed by a meeting between the various researchers. This could potentially have prevented patients being approached by numerous researchers, and would have allowed a more equitable and focused approach to participant recruitment.

A final criticism of the research process was the way in which the tests were administered. These tended to take place at the patients bedside, and were often affected by disturbances on the ward and by staff interruptions. Whilst it may have been appropriate for the RBANS to have been completed at the bedside (as this would reflect the clinical practice of administering a screening test on an acute in-patient setting) it might have been more appropriate for the full battery to have been completed somewhere more conducive to neuropsychological testing. This would have been difficult to arrange for several reasons, including often a lack of participant mobility and limited room space. However, a system could have been organised to book the clinical psychology office based on one of the wards, and with planning and liaising with ward staff, arrangements made for the participant to come to the room for testing. This would have made the testing process more reliable, and may have made it more comfortable and enjoyable for the participants.

The author took a positivist epistemological position. This is to say that the philosophical stance underlying this study was that there is an objective truth underpinning all phenomena, and that this truth can be identified and quantified through scientific investigation. Whilst there are criticisms of such an approach, such as positivism leading to a narrow and artificial understanding of human behaviour and experience (Coolican, 1990), the author believes that such criticisms, whilst potentially valid, relate more to our lack of understanding of such phenomena rather than with problems with the scientific approach itself. Also, positivism is the dominant paradigm underpinning other research related to this study, and though it might have been appropriate to explore this from an alternative viewpoint, the purpose of this study was to explore gaps within the existing approach.

4.5 Future research

Future research into the evaluation of the diagnostic validity of the RBANS could potentially benefit from employing variations on the research design used in this study. The current study used the normative data provided by Randolph (1998) on which to base its conclusions for cognitive impairment /non-impairment. Difficulties with this approach have been highlighted above, and an alternative design would be that used by Nys *et al* (2005) who recruited a matched sample from which to compare the RBANS conclusions. An advantage of a matched control design is that the comparative sample from which the conclusions for cognitive impairment / non-impairment are drawn are potentially better representative of the research sample being investigated, and thus removing the possibility of comparison with a non-representative normative base as discussed above. This would be a considerable advantage when investigating the diagnostic validity (as opposed to the clinical utility) of the RBANS. However, the converse is also true, in that the reported results would not relate as closely to 'real life' clinical practice, where access to a matched control sample would be impossible.

There are also other disadvantages to using a matched control design. Firstly, this type of design would add a significant logistical burden to the recruitment and testing process. Secondly, the problem remains that if the research sample is small, the results may not be generalisable to the wider stroke population. Thirdly, if cognitive impairments are identified within the control population, and these results mean that this participant is withdrawn (as in the Nys *et al*, 2005 study) where is the cut off point made? And related to this, identification of cognitive impairment / non-impairment in the control group would be taken from the normative data, which in effect would mean that the normative data was being applied to the experimental group once removed. Finally, the recruiting of a matched control sample could add in an extraneous variable in the form of the motivation of the matched controls to participate in the study. Rarely do research papers have the space to report these kinds of details, and Nys *et al* (2005) did not report on their recruitment strategy for their control group.

A further consideration for an alternative design to the one used in this study would be to have improved standardisation of the 'gold standard' testing. Having a fixed battery approach, as opposed to a flexible battery approach, would have the advantage of providing a baseline from which to compare other similar studies (Lezak, 2004). However, this would have the effect of distancing the research results from clinical practice. An alternative design would be to use blinded neuropsychological consensus (Duff, 2008), though it would be difficult to control for confounding variables such as potential workplace cultural differences. Ultimately, the evaluation of the diagnostic validity of a screening test is essentially independent of its clinical use, and so the development of a standardised 'gold standard' battery would be of immense value in researching a diagnostically valid screening test of post stroke cognitive impairment.

It would be useful to identify redundant sub-tests within the RBANS to help make it slightly more 'user friendly'. Whilst the reported experience of participants within this study was that the RBANS was generally well tolerated, there were 2 participants who could not complete the test in the acute stage of recovery from stroke. One of these participants later withdrew from the study, and the other completed the RBANS 2 weeks later. Whilst the RBANS was a usable bedside screening test, anything that would reduce the testing load on the patient or increase the brevity and portability of the test, whilst maintaining adequate levels of sensitivity and specificity, would be an advantage. Finally, the results presented here would suggest that further evaluation of the RBANS as a sensitive and specific screening test of post stroke cognitive impairment is warranted.

Word count:

Journal Paper - 4922

Extended Paper - 18983

Total - 23905

References

- Bamford, J., Sandercock, P., Dennis, M., Burn, J., and Warlow, C. (1991). Classification and natural history of clinically identifiable subtypes of cerebral infarction. *Lancet*, 337, 1521–6.
- Barker, C., Pistrang, N., & Elliott, R. (2002). *Research methods in clinical psychology: An introduction for students and practitioners* (2nd Ed.). Chichester, UK: John Wiley & Sons Ltd.
- Beardsall, L., & Brayne, C. (1990). Estimation of verbal intelligence in an elderly community: a prediction analysis using a shortened NART. *British Journal of Clinical Psychology*, 29, 83-90.
- Beatty, W.W. (2004). RBANS analysis of verbal memory in multiple sclerosis. *Archives of Clinical Neuropsychology* 19, 825-834
- Benton, A.L., & Hamsher, K.deS. (1989). *Multilingual Aphasia Examination Manual*. University of Iowa, Iowa City, IA.
- Blake, H., McKinney, M., Treece, K., Lee, E., & Lincoln, N.B. (2002). An evaluation of screening measures for cognitive impairment after stroke. *Age and Ageing* 31. 451-456.
- Bonello J.P., Lisa J. Rapport L.J., & Millis, S.R. (1997). Psychometric properties of the visual object and space perception battery in normal older adults. *The Clinical Neuropsychologist*, 11(4), 436- British Psychological Society [BPS]. (2010). *Psychological services for stroke survivors and their families: Briefing paper 19*. Leicester: The British Psychological Society.

- Burderer, N.M.F. (1996). Statistical methodology: I. Incorporating the prevalence of disease into the sample size calculation for sensitivity and specificity. *Academic Emergency Medicine* 3(9), 895-900.
- Burgess, P.W., & Alderman, N. (2004). Executive dysfunction. In L.H. Goldstein & J.E.McNeil (Eds.). *Clinical neuropsychology: A practical guide to assessment and management for clinicians*. Chichester, UK: John Wiley & Sons Ltd.
- Burgess, P.W. & Shallice, T. (1997). *The Hayling and Brixton Tests: Test manual*. Bury St Edmunds, UK. Thames Valley Test Company.
- Cairns, N.J. (2004). Neuroanatomy and neuropathology. In L.H. Goldstein & J.E.McNeil (Eds.). *Clinical neuropsychology: A practical guide to assessment and management for clinicians*. Chichester, UK: John Wiley & Sons Ltd.
- Cartoni, A., & Lincoln, N.B. (2005). The sensitivity and specificity of the Middlesex Elderly Assessment of Mental State (MEAMS) for detecting cognitive impairment after stroke. *Neuropsychological Rehabilitation*, 15(1), 55-67
- Celani, M.C., Ceravolo, M.G., Duca, E., Minciotti, P., Caputo, N., Orlandini, M., Ricci, S., & Provinciali, L. (1992). Was it infarction or haemorrhage? *Journal of Neurology*, 239, 411-413
- Chaytor, N., Schmitter-Edgecombe, M., & Burr, R. (2006). Improving the ecological validity of executive functioning assessment. *Archives of Clinical Neuropsychology*, 21, 217-227.

- Coolocan, H. (1990). *Research methods and statistics in psychology*. London, UK: Hodder & Stoughton.
- Cullen, B., O'Neill, B., Evans, J.J., Coen, R.F., & Lawlor, B.A. (2007). A review of screening tests for cognitive impairment. *Journal of Neurology, Neurosurgery, and Psychiatry* 78. 790-799
- Darby, D., & Walsh, K. (2005). *Walsh's neuropsychology: A clinical approach* (5th ed.). London, UK. Elsevier.
- Department of Health. (2007). *National stroke strategy*. London: Author
- de Koning, I., van Kooten, F., Koudstaal, P.J., & Dippel, D.W.J. (2005). Diagnostic value of the Rotterdam-CAMCOG in post stroke dementia. *Journal of Neurology, Neurosurgery, and Psychiatry* 76. 263–265
- Donovan, N.J., Kendall, D.L., Heaton, S.C., Kwon, S., Velozo, C.A., & Duncan, P.W. (2008). Conceptualizing functional cognition in stroke. *Neurorehabilitation and Neural Repair*, 22(2), 122-135.
- Duff, K., Bellinger, L.J., Kettmann, J.D.J., & Bayless, J.D. (2006). Pre- and post-right middle cerebral artery stroke in a young adult: A case study examining the sensitivity of the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). *Applied Neuropsychology* 13(3), 194-200
- Duff K., Humphreys Clark, J.D., O'Bryant, S.E., Mold, J.W., Schiffer, R.B., & Sutker, P.B. (2008). Utility of the RBANS in detecting cognitive impairment associated with Alzheimer's disease: Sensitivity, specificity, and positive and negative predictive powers. *Archives of Clinical Neuropsychology*, 23(5), 603-612.
- Evans, J.J. (2003). Basic concepts and principles of neuropsychological

- assessment. In P.W. Halligan, U. Kischka, & J.C. Marshall (Eds.).
Handbook of clinical neuropsychology. Oxford, UK: Oxford University Press.
- Evans, J.J. (2004). Disorders of memory. In L.H. Goldstein & J.E.McNeil (Eds.). *Clinical neuropsychology: A practical guide to assessment management for clinicians*. Chichester, UK: John Wiley & Sons Ltd.
- Folstein, M., Folstein, S., & McHugh, P. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12, 78-85.
- Gold, J.M., Queern, B.A., Iannone, M.A., & Buchanan, R.W. (1999). Repeatable Battery for the Assessment of Neurological Status as a screening test in schizophrenia, 1: Sensitivity, reliability, and validity. *American Journal of Psychiatry*, 156: 1944-1950.
- Goldstein, L.H. (2004). Disorders of voluntary movement. In L.H. Goldstein & J.E.McNeil (Eds.). *Clinical neuropsychology: A practical guide to assessment and management for clinicians*. Chichester, UK: John Wiley & Sons Ltd.
- Harris, R., & Dyson, E. (2001). Recruitment of frail older people into research: Lesson form experience. *Journal of Advanced Nursing*. 36(5). 643-651.
- Hobart, M.P., Goldberg, R., Bartko, J.J., & Gold, J.M. (1999). Repeatable Battery for the Assessment of Neuropsychological Status as a screening test in schizophrenia, II: Convergent/discriminant validity and diagnostic group comparisons. *American Journal of Psychiatry* 156(12), 1951-1957.

- Holtzer , L., Chinet, L., Jaugey, L., Plancherel, B., Sofia, C., Halfon, O., & Randolph, C. (2007). Detection of cognitive impairment with the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) in adolescents with psychotic symptomatology. *Schizophrenia Research* 95(1-3), 48-53
- Hoye, W., Thompson, R., Sherer, M., Nick, t., Gaines, C., Collipp, D., & Vohra, R. (2000). Brief cognitive assessment after stroke: RBANS factor structure and performance patterns. *Journal of the International Neuropsychological Society* 5, 138
- Johnstone , B., & Stonnington, H.H. (Eds). (2001). *Rehabilitation of neuropsychological disorders: A practical guide for rehabilitation professionals*. Philadelphia, PA: Psychology press
- Kendell, R., & Jablensky, A. (2003). Distinguishing between the validity and utility of psychiatric diagnoses. *American Journal of Psychiatry*, 160(1), 4-12.
- Larson, E.B., Kirschner, K., Bode, R.K., Heinemann, A.W., Clorfene, J., & Goodman, R. (2003). Brief cognitive assessment and prediction of functional outcome in stroke. *Topics in Stroke Rehabilitation* 9(4), 10-12.
- Lezak, D.M., Howieson, D.B. & Loring D.W. (2004). *Neuropsychological assessment* (4th ed). New York, NY: Oxford University Press.
- Lincoln, N. (2005). Outcome of cognitive rehabilitation in clinical stroke services. In P.W. Halligan & D.T. Wade (Eds), *Effectiveness of rehabilitation for cognitive deficits*. Oxford, UK: Oxford University Press.

- Lincoln, N.B. (2008). Screening for Cognitive Problems in Acute Stroke.
Nottingham, England. University of Nottingham.
- Manly, T., & Mattingley, J.B. (2004). Visuospatial and attentional disorders. In L.H. Goldstein & J.E.McNeil (Eds.). *Clinical neuropsychology: A practical guide to assessment and management for clinicians*. Chichester, UK: John Wiley & Sons Ltd.
- Mant, J., Wade, D., & Winner, S. (2004). Health care needs assessment: Stroke. In A.Stevens, J.Raftery, J.Mant, & S.Simpson (Eds.). *Health care needs assessment: the epidemiologically based needs assessment reviews* (2nd ed). Oxford, UK: Radcliffe Medical Press
- McKay, C., Wertheimer, J.C., Fichtenberg, N.L., & Casey, J.E. (2008) The Repeatable Battery of Neuropsychological Status (RBANS): Clinical utility in a traumatic brain injury sample. *Clinical Neuropsychologist* 22(2), 228-241.
- McKenna, P. (2004). Disorders of language and communication. In L.H. Goldstein & J.E.McNeil (Eds.). *Clinical neuropsychology: A practical guide to assessment and management for clinicians*. Chichester, UK: John Wiley & Sons Ltd.
- McNeil, J.E. (2004). Disorders of number processing and calculation. In L.H. Goldstein & J.E.McNeil (Eds.). *Clinical neuropsychology: A practical guide to assessment and management for clinicians*. Chichester, UK: John Wiley & Sons Ltd.
- Miller, E. (1992). Some basic principles of neuropsychological assessment. In J.R. Crawford, D.M. Parker, & W.W. McKinlay (Eds.). *A handbook of*

- neuropsychological assessment*. Hove, UK: LEA.
- Meyers, J.E., & Meyers, k.R. (1995). *Rey complex recognition test and trial*. Odessa, FL: Psychological Assessment Resources.
- Mioshi, E., Dawson, K., Mitchell, J., Arnold, R., & Hodges, J.R. (2006). The Addenbrookes Cognitive Examination Revised (ACE-R): A brief cognitive test battery for dementia screening. *International Journal of Geriatric Psychiatry*, 21(11), 1078-1085.
- Morris, R.G., & Kopelman, M.D. (1992). The neuropsychological assessment of dementia. In J.R. Crawford, D.M. Parker, & W.W. McKinlay (Eds.). *A handbook of neuropsychological assessment*. Hove, UK: LEA.
- Nasreddine, Z. (2004). *Montreal Cognitive Assessment*. Retrieved August 25, 2010 from www.mocatest.org.
- National Collaborating Centre for Chronic Conditions. (2008). *Stroke: National guidance for diagnosis and initial management of acute stroke and transient ischaemic attack*. London, UK: Royal College of Physicians.
- Nelson, H.E. (1976). A modified card sorting test sensitive to frontal lobe defects. *Cortex*, 12(4), 313-324.
- Nys, G.M.S., van Zandvoort, M.J.E., de Kort, P.L.M., Jansen, B.P.W., Kappelle, L.J., & de Haan, E.H.F. (2005). Restrictions of the Mini-Mental State Examination in acute stroke. *Archives of Clinical Neuropsychology* 20, 623-629
- Patton, D.E., Duff, K., Schoenberg, M.R., Mold, J., Scott, J.G., & Adams, R.L. (2003). Performance of cognitively normal African Americans on the RBANS in community dwelling older adults. *The Clinical*

Neuropsychologist, 17, 515-530.

Pickering, R.M., Kunkel, D., Fitton, C., Ashburn, A., & Jenkinson, D. (2010).

In-hospital recruitment to observational studies of stroke. *International Journal of Rehabilitation Research*. 33(1):56-63

Powell, J. (2004). The effects of medication and other substances on

cognitive functioning. In L.H. Goldstein & J.E.McNeil (Eds.). *Clinical neuropsychology: A practical guide to assessment and management for clinicians*. Chichester, UK: John Wiley & Sons Ltd.

Randolf, C. (1998). *RBANS manual - Repeatable Battery for the Assessment*

of Neuropsychological Status (RBANS). San Antonio, Tex: Psychological Corp (Harcourt).

Royal College of Physicians. (2008) *National Clinical Guidelines for Stroke*

(3rd ed.). Retrieved January 5, 2009, from <http://www.rpclondon.ac.uk>

Ryusaku, H., Meguro, K., Yamaguchi, S., Ishizaki, J., Ishii, H., Meguro, M., &

Sekita, Y. (2004). Executive dysfunction can explain word list learning disability in very mild Alzheimer's disease. *Psychiatry and Clinical Neuroscience*. 58(1), 54-60.

Scottish Intercollegiate Guidelines Network. (2002). *Management of*

Treatment of Stroke. Retrieved January 5, 2009, from <http://www.sign.ac.uk>

Skilbeck, C. (1992). Neurological assessment in stroke. In J.R. Crawford,

D.M. Parker, & W.W. McKinlay (Eds.). *A handbook of neuropsychological assessment*. Hove, UK: LEA.

Skilbeck, C. (2003). The neuropsychology of vascular disorders. In P.W.

Halligan, U. Kischka, & J.C. Marshall (Eds.). *Handbook of clinical*

neuropsychology. Oxford, UK: Oxford University Press.

- Sorrell, J.H., Zolnikov, B.J., Sharma, A., & Jinnai, I. (2006). Cognitive impairment in people diagnosed with end-stage liver disease evaluated for liver transplant. *Psychiatry and Clinical Neurosciences* 60, 174-181.
- Spitalnic, S. (2004). Test properties 2: Likelihood ratios, Bayes' formula, and receiver operating characteristics. *Hospital Physician*, October 2004, 53-58.
- Syder, D., Body, R., Parker, M., & Boddy, M. (1993). *Sheffield Screening Test for Acquires Language Disorders*. Windsor, UK: Nfer-Nelson.
- Srikanth, V., Thrift, A.C., Saling, M.M., Anderson, J.F.I., Macdonell, R.A.I., & Donnan, G.A. (2003). Increased risk of cognitive impairment 3 months after mild to moderate first ever stroke. *Stroke*, 34, 1136-1143.
- Srikanth, V., Thrift, A.C., Fryer, J.L., Saling, M.M., Dewey, H.M., Sturm, J.W., & Donnan, G.A. (2006). The validity of brief screening cognitive instruments in the diagnosis of cognitive impairment and dementia after first ever stroke. *International Psychogeriatrics*, 18(2), 295-305.
- Stuart-Hamilton, I.(2000). *The psychology of aging: An Introduction*. (3rd Ed). London, UK. Jessica Kingsley Publishers.
- Terryberry-Spohr, L., Gordon, K., & List Kalins, T. (2000). Prediction of functional outcome in the acute rehabilitation setting using the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS). *Abstracts/Archives of Clinical Neuropsychology* 15, 663-664
- Walford, H., Soljak, M., & Majeed, A. (2008). *Stroke prevalence modeling briefing document*. Eastern Region Public Health Observatory.
- Retrieved May 17, 2009, from <http://erpho.org.uk>

- Warrington, E.K., & James, M. (1991). *Visual Object and Space Perception Battery*. Bury St. Edmunds, UK: Thames Valley Co.
- Wechsler, D. (1997a). *Wechsler memory scale – third edition*. San Antonio, TX: Pearson.
- Wechsler, D. (1997b). *Wechsler Adult Intelligence Scale – third edition*. San Antonio, TX: Pearson.
- Wechsler, D. (2010). *Wechsler Memory Scale – fourth UK edition*. San Antonio, TX: Pearson.
- Wilde, M.C. (2006). The validity of the Repeatable Battery for the Assessment of Neuropsychological Status in acute stroke. *Clinical Neuropsychologist* 20(4), 702-715
- Wilks, C.M., Gold, J.M., Bartko, J.J., Dickerson, F., Fenton, W.S., Knable, M., Randolph, C., & Buchanan, R.W. (2002). Test-retest stability of the Repeatable Battery for the Assessment of Neuropsychological Status in schizophrenia. *American Journal of Psychiatry* 159(5), 838-844.
- Willmes, K. (2003). The methodological and statistical foundations of neuropsychological assessment. In P.W. Halligan, U. Kischka, & J.C. Marshall (Eds.). *Handbook of clinical neuropsychology*. Oxford, UK: Oxford University Press.
- Wilson, B.A. (2004). Theoretical approaches to cognitive rehabilitation. In L.H. Goldstein, & J.E. McKnell (Eds.), *Clinical Neuropsychology: A Practical Guide to Assessment and Management for Clinicians* (pp. 345-366). Chichester, England: John Wiley & Sons Ltd.
- Wilson, B.A., Cockburn, J., & Halligan, P. (1987). *Behavioural Inattention Test*. Bury St. Edmunds, UK: Thames Valley Test Co.

Wolfe, C.D.A. (2000). The impact of stroke. *British Medical Bulletin*, 56, 275–86.

APPENDICES

Appendix A – Journal Author Guidelines

International Journal of Stroke

Author Guidelines

The journal to which you are submitting your manuscript employs a plagiarism detection system. By submitting your manuscript to this journal you accept that your manuscript may be screened for plagiarism against previously published works.

The aim of the *International Journal of Stroke* is to concentrate on the clinical aspect of stroke with basic science contributions in areas of clinical interest, and to collate from varying sources, information from all around the world, for the benefit of our readership.

The *International Journal of Stroke* is a peer reviewed journal. All manuscripts will be reviewed by leaders in the appropriate field.

WORD LIMITS

- **Review** manuscripts should be between 4000-8000 words, including references.
- **Research** (previously known as Original articles) should be between 5000 words, including references and any tables.
- **Leading Opinion** manuscripts should be up to 1000 words, including references.
- **Panorama** manuscript should be up to 1000 words, including references.
- **Protocols** should be between 2000-5000 words, including references and any tables or diagrams you may wish to include.
- **Guidelines** should be between 3000-5000 words, including references.

All manuscripts are considered for publication with the understanding that they are submitted to this journal only and have not been published, submitted simultaneously (or accepted for publication) elsewhere; that they are the original work of the author(s); and that they may not be reprinted without the

consent of the *International Journal of Stroke*. Documents should be double spaced throughout.

RESEARCH ARTICLES (formerly known as Original Articles) SHOULD BE STRUCTURED IN THE FOLLOWING WAY:

Documents should be double spaced and structured in the following order:

1. Title page

- Title
- Author name(s)
- Affiliation(s)
- Address of all authors
- Name, address and email of corresponding author to be clear

2. Abstract

Provide a structured abstract according to the following headings:

- Background

- Aims and/or hypothesis
- Methods
- Results
- Conclusions

3. Introduction

4. Aims and/or Hypothesis

5. Methods

6. Results

7. Discussion

8. References

9. Figures, Tables and Illustrations

REFERENCES

These must be limited to the work cited in the paper and should not be a bibliography of the subject. Personal communications and unpublished material ARE NOT ACCEPTABLE as references. Each reference should conform to the Vancouver style, and references should be numbered consecutively in the order in which they are first mentioned in the text. List all authors (include all initials) when there are six or fewer; when seven or more, list the first three and add 'et al'. Give the title of the paper in full; the title of the journal abbreviated according to PubMed; the year; the volume number and the first and last page numbers of the article. Examples:

Standard journal

Siebke H, Breivik H, et al. Survival after 40 minutes submersion without cerebral sequel. Lancet 1995;1:1275-77.

Section of a book

Talley NJ, O'Connor S. Clinical Examination. 5th ed. Minnesota: Churchill Livingstone, 2005;114-17

Chapter in a book

Buckley WE, Nunn T. A rational response to the threat of bioterrorism. In: Plant GW, Blair A, Winston JH Jnr, editors. Primary care in the third millennium. Washington: R McGeddon Inc., 2006;457-72.

Website

Bank of Tanzania. Tanzania: Economic and Financial Indicators. Dar es Salaam, Tanzania: Bank of Tanzania
<http://www.bot-tz.org/Publications/EconomicIndicators/E...> (accessed on Jan 23, 2007).

FIGURES, TABLES AND ILLUSTRATIONS

Illustrations are encouraged for their educational value. Diagrams, line drawings, photographs or flow charts are valuable but their use will be subject to editorial judgment. Photographic illustrations and diagnostic imaging media must be supplied in electronic form. The only acceptable format is Tiff or JPEG file, at 300 dpi.

Go to <http://authorservices.wiley.com/bauthor/illustration.asp> for author guidelines on electronic artwork.

Tables must supplement the text without duplicating it. Each should be numbered, typed on a separate electronic sheet, and have an appropriate title, all manuscripts must be in basic Word format, PDF files cannot be accepted. Please do not create tables as a JPEG file if it can be avoided. They need to be in word format for editing purposes.

Writing tips for authors

These 12 golden rules may assist you with your manuscript, professional writers and editors from around the world use these as their guide.

- 1. Write and edit to express yourself clearly. Do not use flowery or verbose language.*
- 2. Always write and edit your text so that everything can be understood.*
- 3. Always write and edit your work so that nothing can be misunderstood.*
- 4. Say what you mean to say, clearly and simply.*
- 5. Use short sentences.*
- 6. Use short paragraphs.*
- 7. Use the shortest, simplest words possible.*
- 8. Write in the active voice.*
- 9. Avoid unnecessary words.*
- 10. Use verbs for action.*
- 11. Avoid clichés and jargon.*
- 12. If in doubt, leave it out.*

Appendix B – Ethic Committee Correspondence



National Research Ethics Service

Derbyshire Research Ethics Committee

1 Standard Court
Park Row
Nottingham
NG1 6GN

Telephone: 0115 8839461
Facsimile: 0115 9123300

25 February 2010

Mr Steven Green
Trainee Clinical Psychologist
C/o University of Lincoln
Brayford Pool
Lincoln
LN6 7TS

Dear Mr Green

Study Title: Evaluation of the Repeatable Battery For The Assessment Of Neuropsychological Status (RBANS) for screening for cognitive impairment following stroke
REC reference number: 10/H0401/15
Protocol number: 1

The Research Ethics Committee reviewed the above application at the meeting held on 16 February 2010. Thank you for attending to discuss the study.

Documents reviewed

The documents reviewed at the meeting were:

| Document | Version | Date |
|--|-------------------|------------------|
| REC application | 21760/94523/1/283 | 02 February 2010 |
| Protocol | 1 | 18 December 2009 |
| Investigator CV | | 04 February 2010 |
| Participant Information Sheet: Nottingham University Hospitals | 1 | 18 December 2009 |
| Participant Information Sheet: United Lincolnshire Hospitals | 1 | 18 December 2009 |
| Participant Consent Form: Nottingham University Hospitals | 1 | 18 December 2009 |
| Participant Consent Form: United Lincolnshire Hospitals | 1 | 18 December 2009 |
| Evidence of insurance or indemnity | | 06 August 2009 |
| CV - Mark Gresswell | | |
| Assignment Feedback Sheet | | |
| Mini Mental State Examination | | 01 March 2009 |
| RBANS | | |
| List of Full Battery Neuropsychological Tests | | |

This Research Ethics Committee is an advisory committee to East Midlands Strategic Health Authority.
The National Research Ethics Service (NRES) represents the NRES Directorate within the
National Patient Safety Agency and Research Ethics Committees in England.

Provisional opinion

In discussion, the Committee queried the following issues:

1. The Committee asked how you will determine the patient's capability to participate. You explained that ward staff at both sites will identify patients, who will then complete the MMSE and Sheffield Screening tests.
2. The Committee queried why the Lincoln site participants would not be subject to the whole battery of tests. You informed the Committee that there is no clinical psychologist based in Lincoln.
3. The Committee asked if it was worthwhile for the Lincoln site to be included. You concurred that there would not be a huge benefit.
4. The Committee asked for justification of why the test results will not be disclosed. You stated that it may be seen as an inducement to take part. The Committee pointed out that early diagnosis is important to ensure the appropriate treatment. You stated that you have been advised to keep the results separate so there are no advantages to taking part.
5. The Committee asked what the cut-off score is for the full battery test. You could not recall the individual scores but explained that rather than using the total cut-off score you will use the cut-off scores from the individual battery tests looking for impairment. If impairment is found in any one of the battery tests then the participant will be categorised as cognitive impaired.
6. The Committee asked if you are carrying out the study at Lincoln to help increase recruitment and if so a power calculation should be carried out to determine the sample size which may be sufficiently recruited from just the Nottingham site. You agreed that this could be done and was sensible advice.
7. The Committee asked if the RBANS could be carried out sooner than one week after the battery of tests, perhaps the next day. You explained that the one week timescale has been decided on as the clinical psychologist only works two days a week. The Committee pointed out that if the participant's clinical condition had changed over one week this will make the results unreliable. You agreed to randomise the tests as to which will be carried out first.
8. The Committee advised you to remove the participant's name from the questionnaire and a study ID should be used instead.
9. The Committee pointed out that the total time the tests will take has not been fully explained on the PIS. The total time for completion based on the questionnaires' instructions is 2^{1/2} to 3 hours. You agreed to amend this.
10. The Committee advised you not to record the answers to the personal questions on the questionnaire only to score the answers.
11. The Committee informed you that there should be an upper age limit specified on the PIS to correspond to the age validated questionnaires/tests.
12. The Committee asked what the timescale will be between the patient being admitted to hospital and the tests being carried out. You explained that it will be within 48 hours and one week of admission, when the intake assessments have been completed, then the ward team will give the patient the PIS.
13. The Committee asked if the MMSE is widely used in stroke patients. You informed the Committee that it was originally designed for dementia and delirium.
14. The Committee asked if the results may be affected by medication or fatigue and pointed out that it will be important to control the time of day the test is taken.

15. You stated that RBANS has good test re-test reliability and the battery of tests have gold standard validity.

The Committee is unable to give an ethical opinion on the basis of the information and documentation received so far. Before confirming its opinion, the Committee requests that you provide the further information set out below.

The Committee delegated authority to confirm its final opinion on the application to the Chair.

Further information or clarification required

1. The test results should be made available to patients and their families. ✓
2. The sample size should be estimated on the primary aim. A power calculation should be carried out and justification should be given for the inclusion of the Lincoln site if recruitment targets can be met at the Nottingham site. The Lincoln site can only be included if the patients are also recruited for testing the primary aim (i.e. comparison vs full battery test). ✓
3. The following additions/revisions are required on the Participant Information Sheets (PIS):
 - a) The title should be consistent with the one used on the consent forms. ✓
 - b) An upper age limit should be included to correspond with the age validated tests. ✓
 - c) Provide a full explanation of how long the tests take to complete, the name and the total number of the questionnaires to be completed. ✓
 - d) Provide full independent contact details in the event of a participant wishing to make a complaint. ✓
 - e) State that the study has been reviewed by the Derbyshire Research Ethics Committee. ✓
4. The title on the consent forms should be consistent with the one used on the PIS. ✓
5. Remove the participant's name from the RBANS questionnaire and assign a study ID instead. The participant's personal details in answer to the questions should not be recorded on the questionnaire. ✓
6. The tests should be randomised as to which will be carried out first and a question "Has your medical condition changed from last time you completed the questionnaires?" should be added when the second set of questionnaires is completed. ✓
7. Explanation on the statistical analysis is needed, i.e. if they are estimating the positive and negative predictive value. ✓
8. To clarify the cut-off points for each questionnaire in the battery tests for determining cognitive impairment. ✓
9. Clarify if the storage time is 12 months (A43) or 7 years as it is mentioned at PIS. ✓

If you have any queries about the content of this letter, please contact the Co-ordinator.

When submitting your response to the Committee, please send revised documentation where appropriate underlining or otherwise highlighting the changes you have made and giving revised version numbers and dates. It would help to speed up review of your response if you would email your response as well as sending a hard copy.

If the committee has asked for clarification or changes to any answers given in the application form, please do not submit a revised copy of the application form; these can be addressed in a covering letter to the REC.

The Committee will confirm the final ethical opinion within a maximum of 60 days from the date of initial receipt of the application, excluding the time taken by you to respond fully to the above points. A response should be submitted by no later than 25 June 2010.

Membership of the Committee

The members of the Committee who were present at the meeting are listed on the attached sheet.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

| | |
|-------------|--|
| 10/H0401/15 | Please quote this number on all correspondence |
|-------------|--|

Yours sincerely



Mr Phil Hopkinson/Mrs Lisa Gregory
Chair/Committee Coordinator

Email: lisa.gregory@nottspct.nhs.uk

Enclosures: List of names and professions of members who were present at the meeting and those who submitted written comments.

*Copy to: Dr Mark Gresswell
R&D Department for NHS care organisation at lead site – NUH (via email)*

5 Sydney Street
Boston
Lincs
PE21 8NZ

Tel: 01205 354977
07904 524504

email: 08127475@students.lincoln.ac.uk

12th April 2010

Dear Mr Hopkinson

Regarding: REC reference number 10/H0401/15

Study title: Evaluation of the Repeatable Battery For The Assessment Of Neuropsychological Status (RBANS) for screening for cognitive impairment following stroke.

Your review letter dated 25th February 2010.

Thank you for your letter outlining the committee's provisional opinion and requests for further information and clarification. Enclosed are revised versions of the research proposal, Patient Information Sheet, and Consent Forms: all changes and amendments are highlighted in red.

Regarding the requests for further information or clarification, these are as follows:

1. Test results should be made available to patients and their families.

The test results will be recorded in the patient notes and made available to patients and their families.

2. The sample size should be estimated on the primary aim. A power calculation should be carried out and justification should be given for the inclusion of the Lincoln site if recruitment targets can be met at the Nottingham site.

Power calculations to determine the sample size do not exist for evaluations of sensitivity and specificity. This is because the sample size needed is dependent on the prevalence of the disorder (e.g. cognitive impairment) within the sample, which can only be calculated after the sample has been tested (i.e. post hoc). The sample size has therefore been estimated based on previous research sample sizes, the expectation that cognitive impairment is present in

*approximately 70% of people following stroke, and in line with how sample sizes have been estimated for previous research with equivalent designs. The sample size arrived at (30) is a **minimum** sample size (taking into account projected drop out) to give clinically useful information, with the literature reporting a median sample size of 118. The inclusion of the Lincoln site would increase the number of potential participants to 60 (i.e. 30 per site), bringing the sample size for this study closer in line with the reported median sample size, and meaning that by including two sites, we could gather the data in less time. Including an additional site would also make the findings of the study more generalisable, as the results would not be specific to a single ward.*

The Lincoln site can only be included if the patients are also recruited for testing the primary aim (i.e. comparison vs full battery test)

Full battery tests will be administered at the Lincoln site, completed by an Assistant Psychologist under the clinical supervision of Dr Vanessa Dale. This amendment is highlighted in the revised proposal (version 2, dated 29th March 2010).

3. The following additions/revisions are required on the Participant Information Sheets (PIS)

The listed additions/revisions have been completed – please see enclosed PIS (version 2 dated 29th March 2010).

With specific reference to item b (an upper age limit should be included to correspond with age validated tests), the upper age limit has been set at 80 years, as there is good normative data for all the tests up to this age.

With specific reference to item c (provide a full explanation of how long the tests take to complete, the name and the total number of the questionnaires to complete) the tests comprising the full battery are made up of sub-tests of longer tests, to give specific measures of the domains of cognitive impairment under investigation (rather than subjecting the participant to lengthy and

unnecessary full testing). The full list of tests/sub-tests have been included on the PIS and are detailed in the proposal (v2, 29th March 2010).

4. The title on the consent forms should be consistent with the one used on the PIS.

These are now consistent – please see enclosed consent form and PIS (v2, 29th March 2010).

5. Remove the participant's name from the RBANS questionnaire and assign a study ID instead.

A study ID will be used instead of the participant's name on the RBANS, consistent with the study ID allocated on the consent form.

The participant's personal details in answer to the questions should not be recorded on the questionnaire.

These questions will not be asked (as they do not form part of the scoring) and therefore not recorded on the questionnaire.

6. The tests should be randomised as to which will be carried out first and a question "Has your medical condition changed from the last time you completed the questionnaires?" should be added when the second set of questionnaires is completed.

These changes have been made to the design and procedure and are highlighted in the amended proposal (v2, 29th March 2010).

7. Explanation on the statistical analysis is needed, i.e. if they are estimating the positive and negative predictive value.

Positive and negative predictive values will be calculated and are highlighted under data analysis in the amended proposal (v2, 29th March 2010).

8. To clarify the cut-off points for each questionnaire in the battery tests for determining cognitive impairment.

A cut-off score of lower than the 5th percentile (for age adjusted norms) will be used to determine cognitive impairment on each of the battery tests, in line with standard practice (amendment highlighted under data collection in the revised proposal v2, 29th March 2010).

9. Clarify if the storage time is 12 months (A43) or seven years as it is mentioned at PIS.

The data will be securely stored on the ward for a maximum of 12 months, until the research has been completed, then securely stored at the University of Lincoln for 7 years in line with University research guidelines.

Please note that because of the change to randomise the order of administration of the RBANS/full battery tests, consent will not automatically be taken by the chief investigator but by the person who will administer the first set of tests (i.e. this could be the Assistant Psychologist who will administer the full battery tests). The Assistant Psychologist has experience of research to a minimum of undergraduate degree level (as outlined in the IRAS form) and will be working under the direct supervision of a Clinical Psychologist (Dr. Vanessa Dale). The process for ascertaining capacity to give informed consent will remain as before. Also, the procedure in the proposal has been amended to reflect the change of having the same procedure at both sites (i.e. there is now only one standard procedure - see point 2 above).

If I can be of any further assistance, please do not hesitate to contact me.

Yours sincerely

Steve Green

Chief Investigator.



National Research Ethics Service

Derbyshire Research Ethics Committee

1 Standard Court
Park Row
Nottingham
NG1 6GN

Telephone: 0115 8839461
Facsimile: 0115 9123300

13 May 2010

Mr Steven Green
C/o University of Lincoln
Brayford Pool
Lincoln
LN6 7TS

Dear Mr Green

Study Title: Evaluation of the Repeatable Battery For The Assessment Of Neuropsychological Status (RBANS) for screening for cognitive impairment following stroke

REC reference number: 10/H0401/15

Protocol number: 2

Thank you for your letter of 12 April 2010, responding to the Committee's request for further information on the above research, and enclosing the following revised documents:

| Document | Version | Date |
|---|---------|---------------|
| Protocol | 2 | 29 March 2010 |
| Participant Information Sheet: NUH | 2 | 29 March 2010 |
| Participant Information Sheet: ULHT | 2 | 29 March 2010 |
| Participant Consent Form: NUH | 2 | 29 March 2010 |
| Participant Consent Form: ULHT | 2 | 29 March 2010 |
| Response to Request for Further Information | | 12 April 2010 |

The further information and revised documentation has been considered on behalf of the Committee by Vice-Chair.

The Committee was satisfied with the responses to:

1. The test results should be made available to patients and their families.
3. The following additions/revisions are required on the Participant Information Sheets (PIS):
 - a) The title should be consistent with the one used on the consent forms.
 - b) An upper age limit should be included to correspond with the age validated tests.
 - d) Provide full independent contact details in the event of a participant wishing to make a complaint.
 - e) State that the study has been reviewed by the Derbyshire Research Ethics Committee.

This Research Ethics Committee is an advisory committee to East Midlands Strategic Health Authority
The National Research Ethics Service (NRES) represents the NRES Directorate within the
National Patient Safety Agency and Research Ethics Committees in England

WPH 1370

4. The title on the consent forms should be consistent with the one used on the PIS.
6. The tests should be randomised as to which will be carried out first and a question "Has your medical condition changed from last time you completed the questionnaires?" should be added when the second set of questionnaires is completed
7. Explanation on the statistical analysis is needed, i.e. if they are estimating the positive and negative predictive value.
8. To clarify the cut-off points for each questionnaire in the battery tests for determining cognitive impairment.
9. Clarify if the storage time is 12 months (A43) or 7 years as it is mentioned at PIS.

However, the Committee would be grateful for a more complete response on the following points:

2. The sample size should be estimated on the primary aim. A power calculation should be carried out and justification should be given for the inclusion of the Lincoln site if recruitment targets can be met at the Nottingham site. The Lincoln site can only be included if the patients are also recruited for testing the primary aim (i.e. comparison vs full battery test).
 - Power calculations do exist for estimating sample size for sensitivity and specificity. The information from previous research can be used, as mentioned in your reply and your expectation of cognitive impairment of 70% for estimating the sample size. The committee strongly recommend you get advice from a statistician for doing proper power calculations. Moreover, the minimum estimated sample size is the number of patients you should recruit and you cannot exceed this number without justification and further approval from Ethics.
3. The following additions/revisions are required on the Participant Information Sheets (PIS):
 - c) Provide a full explanation of how long the tests take to complete, the name and the total number of the questionnaires to be completed.
 - Clarification on the completion time of each battery test is needed. You are stating 5-10 minutes completion time for the majority of the tests while in the List of Full Battery Tests (originally submitted) it indicates 30-40 minutes for most of them.
5. Remove the participant's name from the RBANS questionnaire and assign a study ID instead. The participant's personal details in answer to the questions should not be recorded on the questionnaire.
 - The revised RBANS questionnaire is not submitted, in which the Study ID is used; instead the participant's name and participant's personal details have been removed.

Additionally, based on the updated information provided please clarify the following:

1. Is the completion time for RBANS 20-30 minutes (as per the protocol, page 9) or 15-20 minutes (as per the PIS, page 2)? Please update the PIS or protocol, as necessary.

2. Will the alternative tests (either full battery or RBANS) be completed again within 2 weeks (as per the protocol, page 9) or within 1 week (as you confirmed in point 7 of the Provisional opinion letter)? Please update the PIS or protocol, as necessary. ✓
3. Evidence of GCP or training in informed consent is needed for the Assistant Psychologist, who will also take informed consent. ✓

Any further revised document submitted should be given a revised version number and date.

The 60 day clock for issue of a final ethical opinion on this application will re-start when the Committee has received a response on the outstanding points.

10/H0401/15

Please quote this number on all correspondence

Yours sincerely



Mrs Lisa Gregory
Committee Co-ordinator

Email: lisa.gregory@nottspct.nhs.uk

Copy to:

Dr Mark Gresswell
R&D office for NHS care organisation at lead site – NUH (via email)

5 Sydney Street
Boston
Lincs
PE21 8NZ

Tel: 01205 354977
07904 524504

email: 08127475@students.lincoln.ac.uk

22nd May 2010

Dear Mr Hopkinson

Regarding: REC reference number 10/H0401/15

Study title: Evaluation of the Repeatable Battery For The Assessment Of Neuropsychological Status (RBANS) for screening for cognitive impairment following stroke.

Your review letter dated 13th May 2010.

Thank you for your letter outlining requests for further information and clarification. Enclosed are revised versions of the research protocol (v3), Patient Information Sheet (v3), Consent Form (v3), amended RBANS, and List of Full Battery tests: all changes and amendments are highlighted in red.

Regarding the requests for further a more complete response, these are as follows:

2. The sample size should be estimated on the primary aim. A power calculation should be carried out and justification should be given for the inclusion of the Lincoln site if recruitment targets can be met at the Nottingham site.

*We have taken advice from Graham Warren (statistician, University of Nottingham) and have used the power calculation to estimate the sample size taken from Buderer (1996). Previous research has indicated that several directly comparable screening tests have good levels of specificity (please see Protocol v3 **Introduction**), and it is estimated that the RBANS will be similar, with an expected specificity of 90%. What is currently missing is a screening test that provides adequate sensitivity. To be considered clinically useful, a sensitivity level of 80% is considered appropriate. The sample size calculation is based on a 95% confidence interval with a width of 10%, and an estimated prevalence of*

*cognitive impairment of 70%. This calculation gives a sample size of 116, taken from the higher figure, which is for specificity, as per Burderer (1996). (The full calculation and justification is highlighted in the revised protocol, version 3, under **Sample Size**).*

The inclusion of the Lincoln site is requested as this would allow access to a greater number of potential participants, as well as allowing for unforeseen eventualities (such as ward closures) and to counteract the expected high drop-out rate. The inclusion of a second site would also have the advantage of allowing greater generalisability of the results, as it would balance potential confounding variables such as particular ward procedures.

The Lincoln site can only be included if the patients are also recruited for testing the primary aim (i.e. comparison vs full battery test)

Full battery tests will be administered at the Lincoln site, completed by an Assistant Psychologist under the clinical supervision of Dr Vanessa Dale, as described in the previous letter dated 12th April 2010.

3. The following additions/revisions are required on the Participant Information Sheets (PIS)

c provide a full explanation of how long the tests take to complete, the name and the total number of the questionnaires to complete – clarification on the completion time of each tests battery is needed

Many of the full tests would take between 30-40 minutes to complete in their totality. However, we will only be administering selected sub-tests (as detailed in the Protocol and PIS) to provide the specific data required for the study. These sub-tests should take no longer than the time indicated in the protocol and the PIS. Many of the tests have a discontinuation rule, meaning that for some participants completion will be faster than for those who complete the full sub-test, hence the range in completion times. Enclosed is a more detailed and

complete version of the List of Full Battery Tests indicating the specific sub-tests that will be used, as well as accompanying published information.

5. Remove the participant's name from the RBANS questionnaire and assign a study ID instead.

A study ID will be used instead of the participant's name on the RBANS, consistent with the study ID allocated on the consent form. Please see enclosed copy of RBANS.

Regarding your requests for further clarification:

1. Is the completion time for the RBANS 20-30 minutes as per the protocol or 15-20 minutes as per the PIS?

Completion time for the RBANS is 20-30 minutes. The PIS (v3) has been amended accordingly.

2. Will the alternative tests be completed again within 2 weeks as per the protocol, or within 1 week as per reply to provisional opinion letter?

The alternative tests will be completed within 2 weeks of the original testing as per the Protocol.

3. Evidence of GCP or training in informed consent is needed for the Assistant Psychologist, who will also be taking informed consent.

The Assistant Psychologist does not at present have formal training in informed consent, though assessing for capacity to give informed consent has formed part of her academic studies. Formal GCP training will be completed by the Assistant Psychologist before data collection begins, and she will not see any patients before it has been completed.

If I can be of any further assistance, please do not hesitate to contact me.

Yours sincerely

Steve Green

Chief Investigator.



National Research Ethics Service

Derbyshire Research Ethics Committee

1 Standard Court
Park Row
Nottingham
NG1 6GN

Telephone: 0115 8839461

Facsimile: 0115 9123300

14 June 2010

Mr Steven Green
Trainee Clinical Psychologist
Lincolnshire Partnership NHS Foundation Trust
5 Sydney Street
Boston
Lincs
PE21 8NZ

Dear Mr Green

Study Title: Evaluation of the Repeatable Battery For The
Assessment Of Neuropsychological Status (RBANS) for
screening for cognitive impairment following stroke

REC reference number: 10/H0401/15

Protocol number: 3

Thank you for your letter of 22 May 2010, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

For NHS research sites only, management permission for research ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at <http://www.rdforum.nhs.uk>.

This Research Ethics Committee is an advisory committee to East Midlands Strategic Health Authority
The National Research Ethics Service (NRES) represents the NRES Directorate within the
National Patient Safety Agency and Research Ethics Committees in England

WPH 1370

Where the only involvement of the NHS organisation is as a Participant Identification Centre, management permission for research is not required but the R&D office should be notified of the study. Guidance should be sought from the R&D office where necessary.

Sponsors are not required to notify the Committee of approvals from host organisations.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

| Document | Version | Date |
|--|-------------------|------------------|
| REC application | 21760/94523/1/283 | 02 February 2010 |
| Investigator CV | | 04 February 2010 |
| Evidence of insurance or indemnity | | 06 August 2009 |
| CV - Mark Gresswell | | |
| Assignment Feedback Sheet | | |
| Mini Mental State Examination | | 01 March 2009 |
| Response to Request for Further Information | | 12 April 2010 |
| Protocol | 3 | 22 May 2010 |
| Participant Information Sheet: Nottingham University Hospitals | 3 | 22 May 2010 |
| Participant Information Sheet: United Lincolnshire Hospitals | 3 | 22 May 2010 |
| Participant Consent Form: Nottingham University Hospitals | 3 | 22 May 2010 |
| Participant Consent Form: United Lincolnshire Hospitals | 3 | 22 May 2010 |
| List of Full Battery Tests | 2 | 22 May 2010 |
| RBANS Front Sheet | | |
| Response to Request for Further Information | | 22 May 2010 |
| COWAT Information | | |
| Visual Object and Space Perception Battery (VOSP) Information | | |
| Rey Complex Figure Test and Recognition Trial (RCFT) Information | | |
| Shortened National Adults Reading Test (NART) Information | | |
| Wechsler Memory Scale - Third Edition Information | | |
| Wisconsin Card Sorting Test (WCST) Information | | |
| Hayling and Brixton Tests Information | | |
| In Depth Review of the BIT | | |

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Service website > After Review

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

The attached document "*After ethical review – guidance for researchers*" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

10/H0401/15

Please quote this number on all correspondence

Yours sincerely



Mr Phil Hopkinson
Chair

Email: lisa.gregory@nottspct.nhs.uk

Enclosures: "After ethical review – guidance for researchers" SL- AR2
Copy to: Lincoln University- Dr Mark Gresswell
R&D office for NHS care organisation at lead site – NUH (via email)

Patient Information Sheet

Title of project: Study to evaluate the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) for detecting cognitive impairment after stroke.

Researchers: S Green, M Gresswell, N Lincoln

We would like to invite you to take part in this research study. Before you decide you need to understand why the research is being done and what it would involve for you. One of our team will go through this information sheet with you and answer any questions you may have.

Talk to others about the study if you wish.

Part 1 of this information sheet tells you the purpose of this study and what will happen to you if you take part.

Part 2 gives you more detailed information about the conduct of the study.

Ask us if there is anything that is not clear or if you would like further information. Take time to decide whether or not you wish to take part.

The study is part of a doctoral training programme in clinical psychology.

Part 1
**WHAT IS THE PURPOSE OF THE STUDY AND WHAT WILL HAPPEN TO
YOU IF YOU TAKE PART?**

What is the purpose of the study?

The study aims to investigate whether a test called the RBANS can identify specific problems with thinking and memory in people who have suffered from a stroke. It is hoped that this test will be better at identifying these problems than other tests that are currently used.

Why have I been invited?

You have been invited to take part in this study because you have recently been admitted to the stroke ward and the staff on the ward have identified you as being someone who might be able to complete the questions on the test. You will only be able to take part if you are aged 80 or under, as some of the tests used in the study may not be reliable for people over this age.

Do I have to take part?

No, it is up to you to decide. We will describe the study and go through this information sheet with you. We will then ask you to sign a consent form to show you have understood what is involved and agreed to take part. You are free to withdraw from the study at any time, without giving a reason. This will not affect the standard of care you receive.

What will happen to me if I take part and what will I have to do?

If you decide you would like to take part you will be asked to complete two sets of tests.

The first of these tests, called the RBANS, will be done with a member of the research team. This test involves answering questions, for instance how many items you can remember from a list, and takes 20 to 30 minutes to complete. This test can be done at your bedside.

The second set of tests will be done with a different member of the research team. These are a more in-depth set of tests and are known as a test battery. This battery is made up of:

- Rey-Osterreith Complex Figure (approximately 5 minutes to complete)
- Wechsler Memory Scale III Logical Memory I (5 minutes)
- Visual Object and Space Perception Test (10 – 20 minutes)
- Behavioural Inattention Test star cancellation (5 minutes)
- Shortened National Adult Reading Test (5 – 10 minutes)
- Controlled Oral Word Association: FAS test (5 minutes)
- WMS III Digit Spatial Span (5 minutes).
- WMS III Letter Number Sequencing (5 minutes)
- WMS III Logical Memory II (5 minutes)
- Rey-Osterreith Complex Figure immediate recall (5 minutes)
- Rey-Osterreith Complex Figure delayed recall (5 minutes)
- Modified Card Sorting Test (5 – 10 minutes)
- Brixton Spatial Anticipation Test (5 minutes)

It is expected that these tests will take a maximum of 1 hour 30 minutes to complete, and you will be able to take breaks whenever you wish. These tests will be done in a side room on the ward, or if you have been discharged we may ask to visit you at your home to complete them.

You may be asked to complete either the RBANS or the battery tests first, and the other tests will be completed a few days later.

The two sets of tests are used to measure strengths and weaknesses in a persons thinking and memory. The results of these two tests will be compared to see if they agree on the strengths and weaknesses that they have or have not identified.

The study will last for about 18 months, though your involvement will only take a week or two, long enough to arrange to complete the two tests.

What are the tests being investigated?

When you were first admitted to the ward, one of the tests you would have done was called the Mini-Mental State Examination (MMSE), which is one of the most commonly used tests to check for possible difficulties in memory and thinking. The Repeatable Battery of Neuropsychological Status (RBANS) is a newer and slightly more in-depth test. Both tests are used to identify areas of thinking and memory that might require further investigation, and have been shown to be good at doing this in patients who have other problems. It is not known how good they are at identifying these problems in people who have had a stroke. The results from the in-depth tests will be used to compare with the results of the MMSE and RBANS to see how good these are at identifying strengths and weaknesses.

What are the disadvantages and risks of taking part?

Doing the tests can take up to one and a half hours, though you will be able to take breaks whenever you need to.

What are the possible benefits of taking part?

It is unlikely that the study will help you directly but we hope that the information we get from this study will help to improve the treatment of people who have had a stroke.

What if there is a problem?

Any complaint about the way you have been dealt with during the study will be addressed. The detailed information on this is given in Part 2.

Will my taking part in the study be kept confidential?

Yes. We will follow ethical and legal practice and all information about you will be handled in confidence. The details are included in Part 2.

If the information in Part 1 has interested you and you are considering participation, please read the additional information in Part 2 before making any decision.

Part 2

DETAILED INFORMATION ABOUT THE CONDUCT OF THE STUDY

What will happen if I don't want to carry on with the study?

You can withdraw from the study at any time, without giving a reason. If you do not wish to continue in the study then any test scores that we have already collected will be identified as yours and withdrawn.

What if there is a problem?

If you have a concern over any aspect of this study, you should ask to speak to the researchers who will do their best to answer your questions – you can do this by asking the ward staff or telephoning directly on 01522 886029. If you remain unhappy, or wish to make a formal complaint, you can do this by contacting the supervisors of this study (contact details are provided at the end of this information sheet) or through the NHS Complaints Procedure by contacting the local Primary Care Trust (Nottingham City PCT) on 0115 845 4545 (the full address is provided at the end of this information sheet).

Will my taking part in this study be kept confidential?

All information which is collected about you during the course of the research will be kept strictly confidential. The results of your tests will be given an anonymous identification number, and the collected data will be kept in a password protected master file. Only the research team will be able to identify you by your identification number. The test sheets will be kept securely filed on the ward throughout the study, and then securely filed at the University of Lincoln until they are destroyed in 7 years time.

What will happen to the results of the study?

It is hoped that the results of the study will be published in an academic journal, so that clinicians involved in working with people who have had a stroke can make more informed decisions about which tests to use when assessing for strengths and weaknesses in thinking and memory.

Who is organising and funding the study?

The study has been organised by the Trent Doctorate in Clinical Psychology, which is run by the Universities of Lincoln and Nottingham, and is funded by Lincolnshire Partnership NHS Foundation Trust, Nottinghamshire Healthcare NHS Trust, and Derbyshire Mental Health Services NHS Trust. The study has been reviewed by the Derbyshire Research Ethics Committee.

Further information and contact details

If you would like further information about how Psychologists do research, this can be found on the British Psychological Society website Research and Science page at www.bps.org.uk

If you would like further support or information about strokes you can contact the Stroke Association on 0845 3033 100 or email info@stroke.org.uk

If you would like further information about this research project please contact:
Steve Green (Chief Investigator),
C/o University of Lincoln,
Health, Life and Social Sciences,
Court 11, Satellite Building 8,
Brayford Pool,
Lincoln LN6 7TS
Telephone 01522 886029.

Study supervisors:

Dr Mark Gresswell (Academic Supervisor)
University of Lincoln,

Health, Life and Social Sciences,
Court 11, Satellite Building 8,
Brayford Pool,
Lincoln LN6 7TS
Telephone 01522 886820

Professor Nadina Lincoln (Research Supervisor)
Institute of Work, Health & Organisations,
University of Nottingham, International House,
Jubilee Campus,
Wollaton Road,
Nottingham NG8 1BB
Telephone 0115 9515315

Local Primary Care Trust:

Nottingham City PCT
1 Standard Court,
Park Row
Nottingham
NG1 6GN
Telephone 0115 845 4545

REC Reference Number: 10/H0401/15

Patient Identification Number:

CONSENT FORM

Title of project: Study to evaluate the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) for detecting cognitive impairment after stroke.

Name of Researcher: Steven Green, University of Lincoln

Academic Supervisor: Dr. Mark Gresswell, University of Lincoln

Clinical Research Supervisor: Prof. Nadina Lincoln, University of Nottingham

Please
initial box

1. I confirm that I have read and understand the information sheet (dated 22nd May 2010, version 3) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason, without my medical care or legal rights being affected.

☐

3. I understand that relevant sections of my medical notes and data collected during the study, may be looked at by individuals from the research team, from regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records.

☐

4. I agree to take part in the above study.

☐

Name of Patient

Date

Signature

Name of Person
taking consent

Date

Signature

If you would like to be notified of the results of the study, please tick here

☐

When completed: 1 for patient; 1 for researcher site file; 1 (original) to be kept in medical